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THE EVOLUTION OF MAN

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THE EVOLUTION OF MAN

ESSAYS BY
G. ELLIOT SMITH
M.A., M.D., LITT.D., D.Sc., F.R.C.P., F.R.S.
Professor of Anatomy in the University of London

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PREFACE
TO THE NEW EDITION

THE first edition of this book consisted of three discourses on the Evolution of Man delivered respectively to the British Association for the Advancement of Science in 1912, the British Academy in 1916, and the Royal Institution in 1924. Hence there was a good deal of repetition and also a lack of uniformity in the mode of presentation in some measure reflecting the three different types of audience to which the addresses were originally given. In the present edition considerable additions have been made to all the chapters, but it would not have been possible, without completely rewriting the book, to eliminate the repetitions. Hence no attempt has been made to do so. But a good deal of matter that was not relevant to the general purpose of the book has been excised from Chapter II. In the former impressions of the book the address to the British Academy was reprinted as it appeared in the Academy's *Proceedings*. This irrelevant matter was included in that chapter because the late Lord Bryce, when inviting me to give the address to the Academy, of which he was then President, expressed the opinion that historians as a class were wofully ignorant of the early history of the Human Family, and suggested that in my attempt to educate them it might be well to indicate how the achievements of the extinct types of mankind might be linked up with the early history of civilization. But as this book deals with the evolution of Man himself I have now eliminated most of the purely cultural references.

During the last two years I have had the benefit of the experience of using this book with a variety of University classes and as a text-book for University extension teaching both in England and America. Most of the additions to the book have been made in response to the needs of such students. I have dealt at some length with the Taungs Ape and the Piltdown Man, because the discussion of their significance so admirably illustrates the general argument. In dealing with the Piltdown skull it became necessary—because there is still such widespread misunderstanding of this vitally important matter—to enter into a detailed account of the reconstruction of the brain-case. This is unavoidably technical, but the numerous inquiries from students emphasized the need for such a statement.

In response to many requests I have gone much more fully than in the earlier impressions into the questions of right- and left-handedness, the erect posture, and the significance of skill in work and play.

I have to express my gratitude to Mr. Humphrey Milford for his generosity in permitting me to triple the number of illustrations, and to Mr. T. L. Poulton for the excellent draughtmanship he has displayed in these figures.

For valuable help in preparing the new edition I have to thank Drs. H. H. Woollard, W. E. Le Gros Clark, and John Beattie and Mr. S. Zuckerman.

The rapid growth of knowledge in the subject discussed in this book is sufficiently indicated in the additions that have become necessary since it was first issued two years ago. Even in the few weeks that have intervened since the manuscript was sent to the

printer many reports have appeared in the daily newspapers of important additions to our information: but the most significant aspect of progress in this department of knowledge is the new insight into the meaning of the evidence, which I have endeavoured to explain in this book.

G. ELLIOT SMITH.

UNIVERSITY COLLEGE,
LONDON.
December 1926.

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In the Foreword (pp. 6–9) an account is given of a fossil tooth found in the Pliocene beds of Nebraska in 1922 that is now in the American Museum in New York, concerning the identity of which competent palaeontologists had expressed diverse opinions, some hinting at the possibility of it being an Ape's, while others regarded it as a Bear's molar. I ventured to make 'the wholly tentative' suggestion (p. 98) that if it proved to be Primate it was more likely to be human than simian. Since this book has been printed, Dr. W. D. Matthew, F.R.S., of the American Museum of Natural History, has informed me that new discoveries in Nebraska afford no corroboration for any of the three suggestions and make it imperative to omit *Hesperopithecus* from the discussion of Man's ancestry.

FOREWORD

MAN'S PEDIGREE

BEFORE we can attempt to discuss the factors that were responsible for the emergence of the distinctive characters of Man, it is essential that we should make some attempt to reconstruct his pedigree, for it is only when the relationships one to the other of the different races of men and the extinct members of the Human Family are defined that one can begin to consider what were the sequence of changes and the essential conditions of progress within the Family. Moreover, without some definite scheme of the position in time and the relationship one to the other of the members of the Order Primates, to which Man belongs, it is impossible to form any idea as to the nature of the factors that determined the emergence of the qualities of mind and body which are distinctive of the Human Family.

I have therefore attempted to construct two diagrams to give graphic expression to the present state of our knowledge regarding these questions of pedigree. In the first figure the relationships of the Human Family itself have been tentatively plotted out. All of the existing members of the Human Family belong to the species *Homo sapiens*. The most primitive race now living is undoubtedly the Australian, which represents the survival with comparatively slight modifications of perhaps the primitive type of the species. Next in order comes the Negro Race, which is much later and, in some respects, more highly specialized, differing profoundly in many respects from the Australian, but sharing with it the black pigmentation of the skin, which is really an early characteristic of the Human Family that primitive Man shares with the Gorilla and the Chimpanzee.

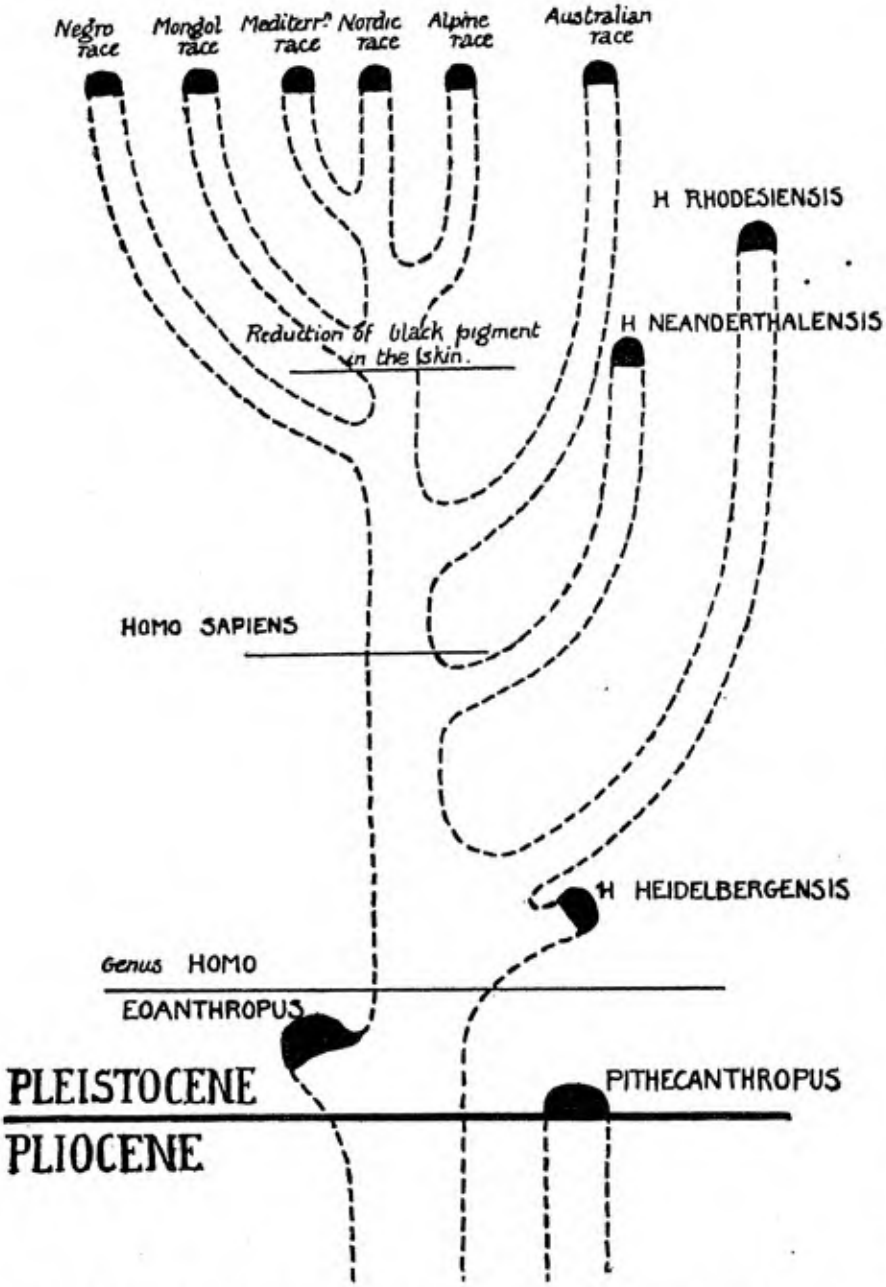

FIGURE 1. A tentative scheme of the relationships of the different genera, species, and races of the Human Family.

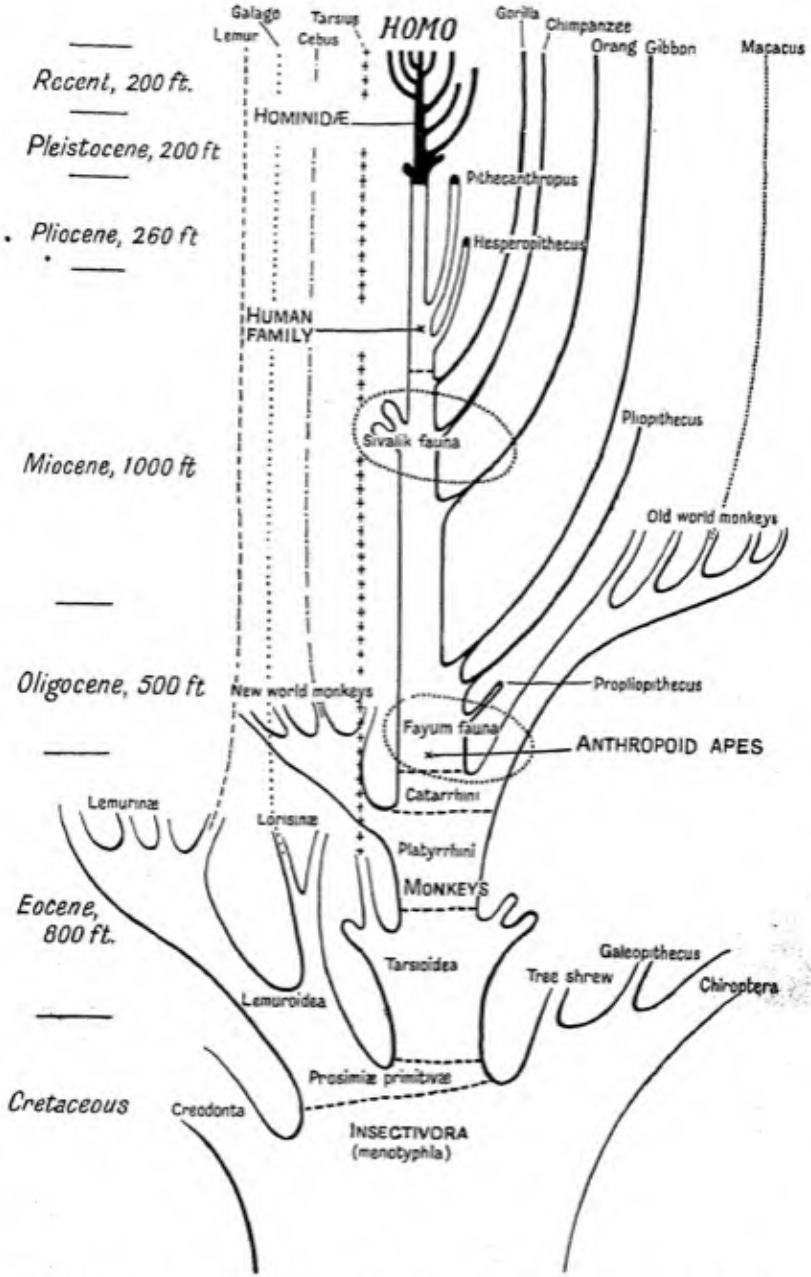

FIGURE 2. A tentative scheme of the relationships of the Order Primates.

After the Negro separated from the main stem of the Family, the amount of pigment in the skin underwent a sudden and very marked reduction; and the next group that became segregated and underwent its own distinctive specialization was the Mongol Race. Yellow pigment is widespread in the skin of many, if not most, living creatures. But its amount is very variable in the races of mankind. It is abundant in Negroes and Australians, but, except in the new-born, is usually disguised by black pigment.

After the separation of the Mongol there was a further reduction of pigment in the skin; and from this white division of mankind the Alpine Race first became split off the main stem, which ultimately became separated into the Mediterranean and the Nordic Races, in the latter of which the reduction of pigment was carried a stage farther to produce the blondest of all human beings.[1]

There are certain individuals that cannot at present be satisfactorily placed in the scheme of Figure 1. Such, for example, are the men who lived in Europe in the so-called Upper Palaeolithic Age. It is possible that these earliest known members of the species *sapiens*, exhibiting as they do a wide range of variation and features severally suggesting Nordic, Mediterranean, Australian, and even Neanderthal affinities, are only the relatively undifferentiated members of the still plastic species that reveal the various potentialities of racial specialization rather than their full realization in stereotyped races. Before *Homo sapiens* came into existence the ancestors of Neanderthal Man became divergently specialized; in the diagram the attempt has been made roughly to locate in time the epoch to which the actual remains of Neanderthal Man belong, and to contrast it with the time at which this species became separated from the ancestors of *Homo sapiens*.

[1] See Chas. B. Davenport, 'The Skin Colours of the Races of Mankind', *Natural History*, New York, 1926, p. 44.

This necessarily involves a certain amount of conjecture, because it places Neanderthal Man, or rather those members of the species whose bones have been found in Europe, about midway up the stem of *Homo sapiens*, whereas no actual remains of the species *sapiens* have been found except at a period subsequent to the disappearance of Neanderthal Man in Europe. The fact that these earliest known members of our species conform as a rule to a higher type than the Australian and the Negro points clearly to the conclusion that these representatives belong to a later phase in the history of the species, and that they were immigrants into Europe when they displaced representatives of the Neanderthal species.

The issues involved in the attempt to solve these problems are of great complexity and difficulty. In Chapter II the nature of the difficulty is set forth with certain suggestions as a tentative interpretation.

The skull found in Rhodesia in 1921 represents a species of the genus *Homo* that is definitely more primitive than Neanderthal Man, although the actual bones which were found in the Broken Hill Mine may be very much more recent in time than the bones of the Neanderthal species, which have been recovered in Europe. In the diagram the attempt has been made to represent these facts graphically, and to show how the ancestors of Rhodesian Man may have sprung from the main stem at a much earlier period than Neanderthal Man, but survived till a more recent period than the latter. This would not be surprising when one considers that in Africa there have been preserved until the present time representatives of much more ancient genera of mammals whose European representatives became extinct at a vastly more ancient time than that assigned in the diagram to the origin of Rhodesian Man.

In the diagram I have assigned the origin of Rhodesian Man to a place near to Heidelberg Man: but at present it is impossible to define the issue more

closely, because the only fragment of Heidelberg Man that we possess consists of a lower jaw, whereas the lower jaw is missing in the case of Rhodesian Man, of whom we possess the skull and some of the limb bones. But the jaw from Heidelberg fits the Rhodesian skull so closely that I have ventured to put the origins of the two species in close apposition, and as we know the date of Heidelberg Man it suggests the time at which the Rhodesian species separated from the main stem of mankind. Heidelberg Man occupies a position at the base of the genus *Homo*. In fact, future discovery may possibly compel us to exclude the Heidelberg remains from that genus, as Bonarelli suggested some years ago: but at present the available evidence favours the inclusion of these remains definitely within the genus *Homo*, and compels us to locate it right at the base of the stem. Apart from the genus *Homo* two other genera of the Human Family are known from the base of the Pleistocene. These are the Piltdown skull representing the genus *Eoanthropus*, which is very closely related to the main stream which eventually emerged as the genus *Homo*, and the earlier and more primitive, but also more highly specialized, Ape-Man of Java, *Pithecanthropus*, the date of which was formerly assigned to the Upper Pliocene, but is now generally believed to belong to the very commencement of the Pleistocene. So that, although we have no fossil bones generally admitted to be human that can be referred to a period earlier than the Pleistocene, the marked contrast between *Pithecanthropus* and *Eoanthropus*, a separation which is not only structural but geographical, makes it quite certain that Man must have existed in the Pliocene, and possibly earlier still.

The consideration of this question brings us to the discussion of the enigmatic tooth found in Nebraska in 1922, which is referred to the Lower Pliocene Period. This tooth, for the reception of which Professor Henry Fairfield Osborn has created a new genus, *Hespero-*

pithecus, is regarded by the American palaeontologists as a representative of a hitherto unknown Primate. So far as its structure is concerned the tooth presents a closer resemblance to that of *Pithecanthropus* than to an Anthropoid Ape's. While the American anatomists[1] regard the tooth as an Ape's, the balance of probability seems to me to favour its identification as a primitive member of the Human Family rather than a new genus of Anthropoid Apes.

The discovery of a single tooth[2] may seem rather a frail and hazardous basis upon which to build such tremendous and unexpected conclusions; and many, if not most, palaeontologists have grave doubts as to the justification for such an interpretation. But the specimen was discovered by a geologist of wide experience, and its horizon has been satisfactorily established. Moreover, the determination of its affinities and its identification as one of the higher Primates closely akin to the Ape-Man of Java, *Pithecanthropus*, has been made by the most competent authorities on the specific characters of fossilized mammalian teeth. I think the balance of probability is in favour of the view that the tooth found in the Pliocene beds of Nebraska may possibly have belonged to a primitive member of the Human Family. It presents the nearest likeness to the corresponding tooth of *Pithecanthropus*; and the fact that the latter was found in what, at the end of the Pliocene Period, was the south-eastern corner of Asia, and the former in North America, which was connected with Eastern Asia by a land bridge enjoying a genial climate, minimizes the difficulty of explaining an identification that at first sight seems to be wholly incredible. For the American palaeontologists have demonstrated that,

[1] William K. Gregory and Milo Hellman, 'Further Notes on the Molars of *Hesperopithecus* and of *Pithecanthropus*', *Bull. Amer. Mus. Nat. Hist.* (1923).

[2] Another tooth was previously found on the same site, but is too much rolled to give much information.

at the time when the original owner of the Nebraska tooth was living, certain Antelopes and Rhinoceroses of Asiatic affinities made their way into America, and for this purpose a land bridge and a warm climate were essential.

Dr. Gregory at one time (1924) believed that 'on the whole . . . its nearest resemblances are with *Pithecanthropus*, and with men rather than with apes'. This conclusion was based upon the study of the features of the tooth; and the claim that it was human was further corroborated by the degree and kind of 'wear', which was unlike that found in any Ape, but of the same nature as occurs in the different genera of the Human Family, and especially *Pithecanthropus*. Since then, however, he has modified his opinion and adopted the view that it is an Ape.

Elsewhere in this book I shall have occasion to criticize Dr. Pilgrim's opinion that the form of the teeth of a long extinct Miocene Ape (*Sivapithecus*) found in India is adequate evidence for its inclusion in the Human Family. The teeth of *Dryopithecus* closely resemble human teeth; but no one now claims it to be anything but an Ape. Ancestors of the Hominidae exhibited such human bodily traits in the Miocene probably long before they acquired those distinctive characters of brain and mind that alone entitle their descendants to human rank. Hence, even if the resemblances of the teeth of *Sivapithecus* to those of Man were closer than they are, this would not justify the inclusion of the former in the Human Family. It would merely suggest its kinship to the ancestors of the Family.

The case of *Hesperopithecus* is somewhat different. It is much more recent, Pliocene instead of Miocene; and therefore much more definitely within the range of Man's possible existence. The tooth presents much closer affinities with those of the most primitive members of the Human Family. But the most important consideration of all, when the extreme susceptibility of

the Anthropoid Apes to a cold climate and their dependence upon forest conditions are considered,[1] is that a primitive human being is much more likely than an Ape to have crossed to America by the northern Pacific bridge.

The real significance of this discovery must remain an enigma until further evidence is forthcoming. But

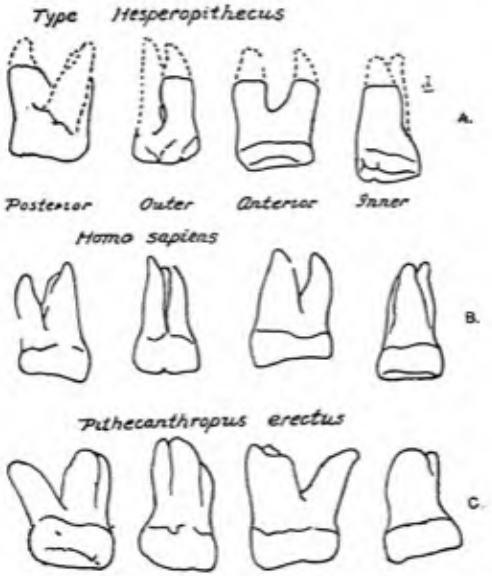

FIGURE 3. The Nebraska Tooth compared with those of *Homo sapiens* and *Pithecanthropus*. (After Gregory.)

the possibilities involved will become more intelligible if we try to put the newly discovered creature into its place in the Primates, as I have attempted to do in Figure 2.

In the second diagram, which is an attempt to represent the position of the Human Family in the Order Primates, this tentative suggestion with reference to *Hesperopithecus* has been graphically expressed.

[1] Henry Fairfield Osborn, *Nature*, 26 August 1922, p. 281.

It must, of course, be understood that with the scanty evidence at our disposal the idea expressed in this diagram is little more than conjecture. But in helping us to understand the nature of the problem at issue it is much more useful to make a concrete proposal that can be criticized and attacked, than merely to play for safety and repress the whole issue as something dangerous that ought to be avoided.

From these wild flights of somewhat hazardous speculation we return to the solid ground of tangible fact. The teeth of the fossil Ape *Dryopithecus*, found in the Miocene and Pliocene beds of India and Europe, had prepared us for the discovery of an Ape revealing a closer structural similarity to Man than any of the living Anthropoids present. Doctors William K. Gregory and Milo Hellman[1] have recently shown how closely the molar teeth in some of the early members of the Human Family resemble those of *Dryopithecus*.

The expectation of finding other extinct Apes that exhibit new tokens of this closer human affinity has now been realized by the discovery of *Australopithecus*; and as Charles Darwin predicted as a possibility in 1871, in Africa. The merit belongs to Professor Raymond A. Dart of making known—under circumstances explained later in this book—the fossilized remains of this hitherto unknown Anthropoid Ape found at Taungs in Bechuanaland in 1924. He had the insight to recognize the vast significance of the discovery. He correctly interpreted its significance as an Ape akin to its African cousins, the Gorilla and Chimpanzee, but revealing definite, if slight, indications of the commencement of changes in the face and brain such as must have taken place to transform an Ape into a member of the Human Family. In Chapter I this fossil will be discussed more fully.

I refer to it now to suggest that its position in the Order Primates might be tentatively indicated if it were

[1] 'The Crown Patterns of Fossil and Recent Human Molar Teeth and their Meaning', *Natural History*, 1926, p. 300.

put in the place of the questionable *Hesperopithecus* in Figure 2, but of course removing its stem of origin below the human rank. Unfortunately the circumstances under which the fossil was found afford no certain in-

FIGURE 4. Drawing of a plaster cast of the face and endocranial cast of the Taungs Ape seen obliquely from the right side. Natural size. Drawn by T. L. Poulton.

dications of its age. It may have been a survival in Pleistocene (or even later) times of a type that left the main stream of Man's ancestry in the Miocene Period.

The first diagram, representing the hypothetical family tree of the Human Family, is so arranged

as to represent the members that have become specialized as branching away from the main stream, which leads to the highest type, and to give graphic expression to the conception that the attainment of the supreme position is not inconsistent with the retention of primitive characters. Those types which have diverged from the main current have all of them become more or less specialized in structure and lost one or other of their primitive characters. For example, the Negro has lost the primitive characters of the hair that the Nordic Race has preserved.

I should make some explanation of my reasons for putting the Nordic Race at the apex of the main stem. In doing so I am not subscribing to those extravagant claims, so popular at the present moment, in virtue of which blondness is regarded as a character that marks this race as supermen. All that is intended in this scheme is to suggest that the bleaching tendencies, of which several distinct phases are found within the Human Family, are carried farthest in the Nordic Race, which also presents a number of primitive traits that other of the human races have lost. On the other hand, the Mediterranean Race has preserved a number of other primitive characteristics, and especially primitive features of brain, which differentiate it from the Nordic Race. But I have separated it from the main stem mainly on the ground of pigmentation.

I have endeavoured to express another fact by putting upon the right-hand side those branches of the Family in which there is great development of the eyebrow ridges or, at any rate, a definite tendency in that direction: whereas I have placed upon the left-hand side of the main stem those races which are distinguished either by an absence or a poor development of the eyebrow ridges. This emphasizes the fact that the development of the eyebrow ridge is not of much importance as an index of race. It is neither an exclusively primitive character nor a distinction of a higher race. It is found developed in *Pithecanthropus*,

Rhodesian Man, Neanderthal Man, and in the Australian and Alpine Races, whereas a defective development of the ridge is characteristic of *Eoanthropus*, the Negro, the Mongol, and the Mediterranean Races, while the Nordic Race occupies a position between the two extremes.

The second diagram indicates the position of the Human Family in the Primate phylum, but is also intended to represent graphically the position and

FIGURE 5. The Spectral Tarsier looks backwards. Drawn by T. L. Poulton.

relations of the whole Order of Primates. Long before the beginning of the Tertiary Period a group of Insectivora had become separated from other mammals, from which they are distinguished by the preservation of features of an extremely primitive character very closely akin to those of the lowlier Marsupials of Australia and America. These creatures, represented to-day by the Jumping Shrews of Africa and the Tree Shrews of the Malay Archipelago, are known as the Menotyphla, and they are closely akin to the fossil group of Creodonta, from which the Carnivora were

derived. On the other side they are closely related to the primitive flying mammal known as *Galeopithecus* and the Chiroptera, consisting of the Bats and the Flying Foxes.

The adoption by some of these Shrews of the habit of living in trees exposed them to conditions that favoured the development of profound changes in the relative proportions of the brain. The sense of vision became enhanced in importance, and the sense of smell correspondingly reduced: but in addition the senses of touch and hearing, and the power of agility of movement, were considerably enhanced. In one of these groups the importance of vision became still further increased, and the result of this was to bring into existence the Order Primates. This happened in the Upper Cretaceous, at the phase represented in the diagram by the Prosimiae primitivae.

Before the beginning of the Tertiary Period these primitive Prosimiae had split into two branches, the Lemuroidea and the Tarsioidea,[1] the fundamental distinction between the two being a further enhancement of the importance of vision, which, in the Tarsioidea, became the dominant sense, definitely usurping the position occupied by smell as the chief guide to the animal, which is found not only in the primitive mammals, but is still retained even in the Lemurs. Of the Tarsioidea one member has survived to the present day with comparatively slight change from the very beginning of the Eocene Period as the Spectral Tarsier which is still found in Borneo, Java, and the Philippines.

Tarsius is an example of what has been called 'a living fossil', a link not only between the Prosimiae and the Simiae but also between Eocene times and the present. It can look backward (Fig. 5) and forward

[1] The differentiation is so profound that it is necessary (in giving adequate expression to it) to make the Lemuroidea and Tarsioidea distinct Suborders of the Primates, of which the latter only is closely related to the Monkeys and Apes. See on this subject the Discussion on *Tarsius* (*Proc. Zool. Soc. London*, 1919).

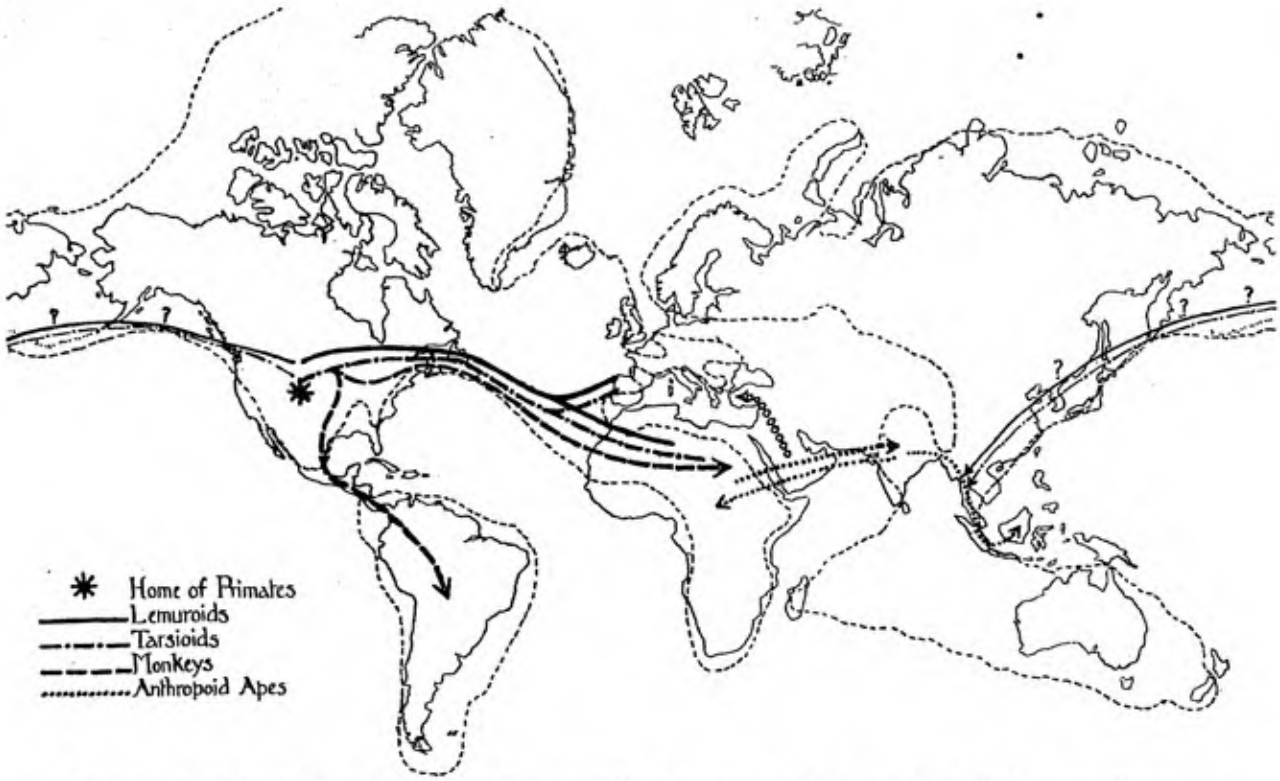

FIGURE 6. Map to illustrate the wanderings of the Primates. The Eocene land bridges are shown in accordance with information supplied by Professor D. M. S. Watson, F.R.S.

(Fig. 9), not only in the actual but also in the metaphorical sense of these significant words.

Before the close of the Eocene Period one of the Tarsioidea acquired the power of stereoscopic vision and became transformed into a primitive Monkey with a very considerable increase in the size of the brain and an enormous enhancement of the power of skilled movement and of intelligence. At this stage in the evolution of the Primates, which occurred somewhere in the neighbourhood of Central America, representatives of all three branches, Lemurs, Tarsioids, and Monkeys, wandered from the New World to the Old, across bridges that stretched from North America to Africa and Europe, and possibly also from North America to Eastern Asia (Fig. 6).

The Monkeys that wandered across the Atlantic seem to have undergone a profound change during their journey, for, at the beginning of the Oligocene, we find in the Egyptian Fayum representatives of two new types of Monkeys, the tailed Catarrhines of the Old World, and the Anthropoid Apes, represented by a diminutive creature known as *Propliopithecus*. These Anthropoids wandered far and wide in Africa, Europe, and Asia, increasing in size as their power of adaptation increased, and in the middle of the Miocene Period in Northern India a great number of new varieties had come into existence, including the ancestors not only of the Giant Apes, but also of the Human Family.

The object of the diagram (Fig. 2), like the previous one (Fig. 1), is to indicate the fact that all these Lemurs, Monkeys, and Apes, which have become specialized in one way or another, should be regarded as having departed from the main stream of development that leads straight up to Man, and by doing so lost something of the primitive structure and plasticity that were necessary for the attainment of the high powers of adaptation which represent one of the most distinctive characteristics of the Human Family.

In the map (Fig. 6) some idea of the extensive wanderings of the Primates is suggested. Before the beginning of the Tertiary Period members of the Lemuroidea and Tarsioidea were living in North America. In the Eocene Period they wandered across the land bridge to south-western Europe and Africa, but not before some of the latter group had given birth to Platyrrhine Monkeys, which found an asylum in South America, where they have persisted until the present day. Of the three groups that wandered across the Atlantic bridge to the Old World—Lemurs, Tarsioids, and Monkeys—the latter underwent the most profound change, and became split up into two divisions—the tailed Catarrhines and the tailless Anthropoid Apes, the diminutive representatives of which have been recovered from the Lower Oligocene beds of the Egyptian Fayum.

Some of the migrations indicated on the map occurred after the Eocene Period when new land connexions were established. The wanderings of Monkeys into South America and from Africa to India fall into this category.

For further information (and references to original sources) relating to the subject of this Foreword see William K. Gregory's memoirs: 'Studies in the Evolution of Primates', *Bull. Amer. Mus. Nat. Hist.* (1916); 'On the Structure and Relations of *Notharctus*, an American Eocene Primate', *Mem. Amer. Mus. Nat. Hist.* (1920); and *The Origin and Evolution of the Human Dentition* (1921). Mr. J. Thornton Carter's important observations 'On the Structure of the Enamel in the Primates', *Proc. Zool. Soc. Lond.*, 1922, p. 599, afford independent corroboration of the views expounded here.

For evidence of the presence of Tarsioids in Europe in Eocene times see Pierre Teilhard de Chardin, 'La présence d'un Tarsier dans les phosphorites du Quercy et sur l'origine tarsienne de l'homme', *L'Anthropologie* (1921, p. 329).

CHAPTER I

THE EVOLUTION OF MAN[1]

The Scope of Evolution.

In an address delivered at the University of Manchester some years ago Lord Morley[2] referred to 'evolution' as 'the most overworked word in all the language of the day'; nevertheless, he was constrained to admit that, even when discussing such a theme as history and modern politics, 'we cannot do without it'. But to anthropologists concerned with the problems of Man's nature and the gradual emergence of human structure, customs, and institutions, the idea of evolution finds more obvious expression than most of us can detect in modern politics. In such circumstances there is a risk of 'overworking' not only the word 'evolution' but also the application of the idea to the material of their investigations.

In 1911 Dr. W. H. R. Rivers uttered a protest against the tendency, to which anthropologists of the present generation[3] seem to be peculiarly prone, to apply the term 'evolution' to certain hypotheses in cultural anthropology that are the very antithesis of what the biologist means when he uses the word.

I need offer no apology for repeating and emphasizing some of the points brought forward in Dr. Rivers's deeply instructive address. His lucid and convincing account of the circumstances that compelled him to change his attitude toward the main problems of the history of human society in Melanesia illustrate the

[1] Address delivered at Dundee to the Anthropological Section of the British Association for the Advancement of Science in September, 1912. (*Nature*, London, 26 September 1912; and *Annual Report of the Smithsonian Institution*, 1912.)

[2] *History and Politics*, 1912.

[3] Presidential Address to the Anthropological Section of the British Association.

true scientific method. Instead of trying to force his evidence into conformity with a dogma, he frankly admitted that the facts he had collected could not be made to harmonize with the fashionable method of interpretation. Therefore he had no option other than to abandon the theory thus shown to be false. He told us that in his first attempts to trace out 'the evolution of custom and institution' he started from the assumption that 'where similarities are found in different parts of the world they are due to independent origin and development, which in turn is ascribed to the fundamental similarity of the workings of the human mind all over the world. So that, given similar conditions, similar customs and institutions will come into existence and develop on the same lines.' But when he submitted to critical examination the evidence he had collected he found that such an attitude would not provide an adequate explanation of the facts, and he was forced to confess that he 'had ignored considerations arising from racial mixture and the blending of cultures'.

I do not recall these statements merely for the purpose of emphasizing the far-reaching significance of an address that is certain to be looked back upon as one of the most distinctive and influential utterances in the recent history of anthropology. My intention is rather to emphasize the contrast between this false conception of the meaning of the word 'evolution' and its true use. For it is the aim of this book to investigate the domain of anthropology in which unequivocal evolutionary factors have played a definite role; I refer to the study of Man's pedigree and the forces that determined the precise line of development of his ancestors and ultimately fashioned Man himself.

It is inevitable in these days that one trained in biological ways of thought should approach the problems of anthropology with the idea of evolution as his guiding principle. But the conviction must be reached, sooner or later, by every one who conscientiously, and

with an open mind, seeks to answer most of the questions relating to Man's history and achievements within the last sixty centuries, that the evidence of true evolution within that period is very insignificant. Evolution needs vast periods of time for its operations. Most of the factors that call for investigation concerning the history of Man and his works are unquestionably the direct effects of the intermingling of races and cultures.

But I would not have you misunderstand my meaning. Nothing could be farther from my intention than to question the reality of evolution, as understood by Charles Darwin, and the tremendous influence it is still exerting upon mankind. In respect of certain perils Man may, perhaps, have protected himself from 'the general operation of that process of natural selection and survival of the fittest which up to his appearance had been the law of the living world' (Sir Ray Lankester). But it has been demonstrated quite definitely that Man, in virtue of these very heightened powers, which, to some observers, seem to have secured him an immunity from what Sir Ray Lankester calls 'nature's inexorable discipline of death', is constantly exposing himself to new conditions that favour the operations of natural selection, as well as other forms of 'selection' to which his increased powers of intelligent choice and his subjection to the influences of fashion and tradition expose him.

It is not, however, with such contentious matters as the precise mode of operation of evolution at the present day that I propose to deal; nor yet with the discussion of when and how the races of mankind became specialized and differentiated the one from the other. It is the much older story of the origin of Man himself, and the first glimmerings of human characteristics amidst even the remotest of his ancestors, to which I invite you to give some consideration.

In their book, *Evolution*,[1] Professors J. Arthur Thomson and P. Geddes make the statement that 'the

[1] 1912, p. 102.

uncertainties as to Man's pedigree and antiquity are still great, and it is undeniably difficult to discover the factors in his emergence and ascent'. There is still some divergence of opinion as to the precise pedigree; nevertheless, there now seems to be ample evidence available to justify a tentative sketch of the genealogy of Man and to display the essential facts of his pedigree as far back as Eocene times—a matter of several million years—with at least as much confidence as in the case of any other recent mammal. If all the factors in his emergence are not yet known, there is one unquestionable category of evidence that we can seize hold of and examine—the steady and uniform development of the brain along a well-defined course throughout the Primates right up to Man—which must give us the fundamental reason for 'Man's emergence and ascent', whatever other factors may contribute towards that consummation.

What I propose to attempt is to put into serial order the vertebrates that we have reason to regard as the nearest relatives to Man's ancestors now available for examination. Then it becomes possible to determine what outstanding changes in the structure of the cerebral hemispheres have taken place at each upward step that may help to explain the gradual acquirement of the distinctive intellectual powers, which, by immeasurably increasing the power of adaptation to varying circumstances, and in all probability modifying the process of sexual selection, have made Man what he is at present.

The links in the chain of our ancestry supplied by palaeontology are few and of doubtful value if considered apart from the illumination of comparative anatomy. But when the evidence afforded by fossil remains is added to that revealed by the structure, functions, and development of living animals a very impressive history of Man's origin emerges.

Psychologists have formulated certain necessary phases through which the evolution of intelligence must

have passed in the process of the gradual building up of the structure of the mind. The brain in a sense is the incarnation of this mental structure. The evolution of the brain should therefore enable us to unite into one comprehensive story the accumulations of knowledge concerning the essential facts involved in the study of Man's origin. We can thus combine the factors that have contributed to his emergence, which have been gathered by workers in such diverse departments of knowledge as zoology and comparative anatomy, geology and palaeontology, and physiology and psychology.

It was the evolution of the brain and the ability to profit by experience, which such perfecting of the cerebral mechanism made possible, that led to the emergence of mammals. I have already explained the reasons for this claim in the address on the origin of mammals at the Portsmouth meeting of the British Association.[1] From the Mammalia, by a continuation of this process of building up the cerebral cortex, or, if you prefer it, the structure of the mind, was eventually formed the living creature that has attained the most extensive powers of discrimination, skill, and understanding.

The study of the brain and mind, therefore, should have been the first care of the investigator of human origins. Charles Darwin, with his usual perspicuity, fully realized this; but since his time the role of intelligence and its instruments has been almost wholly ignored in these discussions, or, when invoked at all, wholly irrelevant aspects of the problem have usually been considered. There can be no doubt that this neglect of the evidence revealed in the comparative anatomy of the brain is in large measure due to the discredit cast upon this branch of knowledge by the singularly futile pretensions of some of the foremost anatomists who opposed Darwin's views in the dis-

[1] Discussion on the 'Origin of Mammals' at the meetings of Section D (*Brit. Assoc. Report*, 1911, p. 424).

cussions which took place at the meetings of the British Association and elsewhere half a century ago. Charles Kingsley poured delightful ridicule on these learned discussions in the pages of *Water Babies*. The controversy excited by Sir Richard Owen's contention that the great distinctive feature of the human brain was the possession of a structure that used to be called the *hippocampus minor* was not unjustly the mark of his scathing satire.

> 'The professor had even got up at the British Association and declared that apes had hippopotamus majors in their brains, just as men have. Which was a shocking thing to say; for, if it were so, what would become of the faith, hope, and charity of immortal millions? You may think that there are other more important differences between you and an ape, such as being able to speak, and make machines, and know right from wrong, and say your prayers, and other little matters of that kind; but that is only a child's fancy, my dear. Nothing is to be depended upon but the great hippopotamus test. If you have a hippopotamus major in your brain, you are no ape, though you had four hands, no feet, and were more apeish than the apes of all aperies. Always remember that the one true, certain, final, and all-important difference between you and an ape is that you have a hippopotamus major in your brain and it has none. If a hippopotamus was discovered in an ape's brain, why, it would not be one, you know, but something else.'

The measure of the futility of the contention thus held up to scorn can be more justly realized now. Some years ago I pointed out[1] that the feature referred to in Kingsley's burlesque phrase, 'hippopotamus major', which Owen claimed to be distinctive of the human brain, and Huxley maintained was present also

[1] *Trans. Linn. Soc. Lond.*, Second Series; *Zoology*, vol. viii, part 10, 1903.

in Apes, is quite a primitive characteristic, and the common property of the Mammalia in general. Moreover, the claim made by Owen had not even the merit of novelty: for the French anatomist Serres had disposed of it thirty years before Owen revived it in 1857.

This illustration of the nature of the discussions that distracted attention from the real problems, although the most notorious one, is unfortunately characteristic of the state of affairs that prevailed when prejudice blinded men's eyes to the obvious facts calling so urgently for calm investigation.

Man's Pedigree.

Any one who is familiar with the anatomy of Man and the Apes must admit that no hypothesis other than that of close kinship affords a reasonable or credible explanation of the extraordinarily exact identity of structure that obtains in most parts of the bodies of Man and Gorilla. To deny the validity of this evidence of near kinship is tantamount to a confession of the utter uselessness of the facts of comparative anatomy as indications of genetic relationships, and a reversion to the obscurantism of the Dark Ages of biology. But if any one still harbours an honest doubt in the face of this overwhelming testimony from mere structure, the reactions of the blood will confirm the teaching of anatomy; and the susceptibility of the Anthropoid Apes to the infection of human diseases, from which other Apes and mammals in general are immune, should complete and clinch the proof for all who are willing to be convinced.

The significance of the blood tests, which were investigated more than twenty years ago by Professors Uhlenhuth, Nuttall, Friedenthal, and others, is so important that special attention must be called to them. Professor Nuttall of Cambridge devoted a whole book[1] to the consideration of the subject, in which he referred to 'the remarkable fact that a common property has

[1] *Blood Immunity and Blood Relationship*, 1904.

persisted in the bloods of certain groups of animals throughout the ages which have elapsed during their evolution from a common ancestor, and this in spite of differences of food and habits of life'.

These distinctive biochemical reactions of the blood are revealed by what is known as the precipitin test, which is applied in the following way. Into a vein of a living Rabbit five cubic centimetres of blood-serum (of Man, Ape, or other animal) are injected, and after suitable intervals the inoculation is repeated five times. After a week or more the Rabbit is killed and its blood collected and allowed to coagulate. The fluid that remains after the clotting is complete is then collected and is called the anti-human (or anti-chimpanzee or anti-baboon or anti-any-other-animal) serum. It is usual to add a few drops of chloroform to the serum for preservative purposes and then keep it in small glass tubes with sealed ends.

If into any of these tubes the fresh serum of an animal of the same species be introduced a thick precipitate is thrown down. If the serum of a nearly related animal is used there will also be a precipitate, but not so dense as that of the same species; and the relative intensity of the precipitin reaction affords an index of the degree of kinship of the animals whose sera are mixed. An anti-chimpanzee serum yields a dense precipitate if the fresh serum of Man, or any Anthropoid Ape, be added to it. This is regarded as proof of the close kinship of all the Anthropoid Apes not only one with each other but also with Man. If similar tests be applied to the Cercopithecidae, i.e. Monkeys of the Old World (Baboons, Macaques, &c.), it will be found that the density of the precipitate is very appreciably less. In the case of the Cebidae and Hapalidae, Monkeys of the New World (Capuchins, Howlers, Marmosets, &c.), only a slight cloudiness is produced by human serum when introduced into their respective anti-sera. In the Tarsioids (according to Le Gros Clark) and the Lemuroids no precipitation at all can

be detected. Hence Professor Nuttall came to the conclusion that the evidence of the blood tests indicates an intimate kinship of Man to the Anthropoid Apes, a much more distant relationship to the Cercopithecidae, and an even more remote connexion with the Cebidae and Hapalidae. His failure to obtain any reactions with the sera of Lemurs led him to come into line with those zoologists, such as Hubrecht, Max Weber, and others, who exclude the Lemurs from the Order Primates. But Mr. Le Gros Clark's failure to obtain any precipitate from the serum of *Tarsius*, whose close kinship to the Anthropoidea no one questions, indicates that, however valuable positive precipitin tests may be as indications of close affinity or degrees of relationship, distantly related members of the same Order may fail to yield any reaction. What such tests do indicate is that *Tarsius* cannot be a near relative of Man, although we know it to be closely related to the primitive Anthropoidea.

With reference to the evidence afforded by the liability to infection by disease, it has been shown that (within the Order Primates) if a series of Monkeys and Apes be inoculated with syphilis the virulence of the disease increases with the nearness of the animal to Man. The Chimpanzee is more violently affected than the Orang, while the Baboon and the Macaque are let off much more lightly.

Hence these vital reactions of blood relationship and the liability to disease corroborate the inferences from the anatomical evidence that the Anthropoid Apes are in reality much more closely akin to the Human Family than any other Primates.

In addition to the evidence of far-reaching kinships revealed by the *precipitin* tests the blood also provides evidence, by what is known as the reactions of *agglutination*, of differences within the same species and in individuals of the same community. Although this phenomenon has been known for some time, the peculiar nature of its distribution (suggestive of Mendelian

segregation) was not discovered until 1901, when Dr. Karl Landsteiner called attention to the fact that four classes of blood were found in Man. When the blood of one individual causes a kind of clotting or agglutination of the red-blood corpuscles in the blood of a second person, it may be due to either of two substances, distinguished as *A* or *B*, in the blood of the latter. More than 46 per cent. of English people have neither of these agglutination substances in their blood. They represent what is known as Group I. Group II consists of those people (more than 43 per cent. of English people) whose blood corpuscles contain Substance *A*. Group III is composed of those people (only about 7 per cent. of English people) whose blood contains Substance *B*. Whereas Group IV (3 per cent. of English) includes all people who have both Substances *A* and *B* in their blood.

A wide range in the relative proportions of these four groups is found among various peoples, Group III rising to about 35 per cent. in the Mongolian Race and to nearly 30 per cent. in Negroes. But the evidence at present available is very puzzling. The distribution of the groups cannot be brought into harmony with either racial distributions or geographical conditions. No doubt in time further research will reveal some explanation of facts that are obviously of great importance. But I would not have referred to this unsolved enigma now if Dr. Landsteiner had not recently found that Substances *A* and *B* were present (in proportions that vary in different genera) in the blood of Anthropoid Apes, thus adding further proof of their close relationship to the Human Family, and suggesting that the blood-groups were established before the Apes and Men had become differentiated one from the other.[1] Still more recently Dr. Laurence H. Snyder[2] has

[1] Reuben Ottenberg, 'The Relationship of Races as shown by Blood Characteristics', *Natural Science*, 1926, p. 80.

[2] 'Human Blood Groups: Their Inheritance and Racial Significance', *American Journal of Physical Anthropology*, vol. ix, 1926, p. 233.

added further to our knowledge of this subject. He states that while blood-grouping is not found in lower animals it may occur in Anthropoid Apes. These biological reactions confirm the evidence of anatomy and embryology that the Anthropoid Apes are closely akin to the Human Family.

For more than a century anatomists have been attempting to define in what respects Man's structure can be differentiated from that of the Anthropoid Apes. Time and again the claim has been made that either Man or the Ape has some anatomical feature definitely distinctive of it. But in every case such pretensions have been shown to be unfounded. Elsewhere in this book I have referred specifically to several claims of this sort that have been made in respect of features of the brain. In the anatomy of the rest of the body the last survivor of these false claims was the muscle in the leg known as the *peroneus tertius*. This muscle was for many years repeatedly mentioned as a distinctively human characteristic, although it is not uncommon for it to be absent, especially in Negroes, Australians, and other lowly races. But its presence has recently been recorded in a Gorilla and a Chimpanzee. Hence it shares the fate of every other anatomical feature claimed to differentiate Man from the Apes. The facts of anatomy are, in fact, decisive as to Man's close kinship with the Gorilla and Chimpanzee. Doctors Gregory and Hellman have recently reaffirmed the evidence afforded by the teeth. Man and the Apes share in common many curious details of dental patterns found in no other animals, which cannot be explained by the theory of convergence or in any credible way other than community of origin and close kinship. In the same number of the same Journal (*Natural History*, 1926, p. 310) Dr. Dudley J. Morton once more demonstrates how the evidence of the structure of the feet of Men and Apes tells the same story. But one can compare any organ or part of the body and in every case find overwhelming evidence of structural

homologies of so exact a kind as to establish the reality of a kinship between Man and Ape that is much closer than that linking either to the other Primates.

At a time when palaeontologists have been disputing for fourteen years whether the Piltdown jaw is human or simian, and for more than thirty years whether the brain-case of *Pithecanthropus* is that of a Man or a Gibbon, it is surely futile to deny the anatomical likenesses and the closeness of the relationship. The problem that is now being forced upon our consideration is not whether such kinship is real; but rather whether the facts will not compel us to accept Friedenthal's suggestion and merge the Simiidae and Hominidae into one Family. If we ourselves did not belong to the latter Family and suffer from the bias such relationship confers, no zoologist would be justified by the concrete facts of the case in putting the Anthropoid Apes into another Family.

The Gibbon is the most primitive as well as the most ancient of the Anthropoid Apes, nearly akin to the common ancestor of Man, the Gorilla, the Chimpanzee, and the Orang, and one of the important connecting links between them and the tailed Monkeys (Catarrhines) of the Old World, from one of whose remote (probably Eocene) ancestors the Anthropoid Apes were derived. The Gibbon itself has persisted with singularly little change since Miocene times when *Pliopithecus*, the name under which the fossil Gibbon is known, ranged from Western Europe to Asia. Like the modern Gibbon it was much smaller than the Giant Apes. But its own ancestor *Propliopithecus*, whose remains were found in the Egyptian Fayum in 1911, was smaller still and very primitive. It was found in Early Oligocene beds with the remains of a little tailed Monkey (*Parapithecus*), which can be regarded as a survival from Eocene times of the Catarrhine ancestor of *Propliopithecus*. It is equally certain that the Catarrhine Monkeys were derived from some primitive Platyr-

rhine, the other, less modified, descendants of which we recognize in the South American Monkeys of the present day. The common ancestor of all these Primates was a creature nearly akin to the curious little Spectral Tarsier that still haunts the forests of Borneo, Java, and the neighbouring islands.

This much of Man's pedigree will, I think, be admitted by the great majority of zoologists who are familiar with the facts. But I believe we can push the line of ancestry still farther back, beyond the most primitive Primate into Haeckel's suborder Menotyphla, which most zoologists regard as constituting two families of Insectivora. I need not stop to give the evidence for this opinion, for most of the data and arguments in support of it have been summarized most excellently by Dr. W. K. Gregory,[1] and still more recently corroborated by the careful observations of Mr. W. E. Le Gros Clark [2] and Dr. H. H. Woollard.[3]

This group includes the Oriental Tree Shrews and the African Jumping Shrews. The latter (Macroscelididae), living in the original South African home of the Mammalia, present extraordinarily primitive features linking them by close bonds of affinity to the Marsupials. The Tree Shrews (Tupaiidae), however, which range from India to Java, while presenting very definite evidence of kinship to their humble African cousins, also display in the structure of their bodies positive evidence of relationship to the stem of the aristocratic Primate phylum.

Quite apart from such similarities as might tentatively be attributed to identical habits and habitats, there are many structural identities in the Tree Shrews

[1] 'The Orders of Mammals', *Bull. Amer. Mus. Nat. Hist.*, vol. xxvii, 1910, p. 321.

[2] 'On the Brain of the Tree-Shrew (*Tupaia minor*)', *Proc. Zool. Soc. London*, 1924, p. 1053; 'On the Myology of *Tupaia minor*', *ibid.*, 1924, p. 461; 'On the Skull of *Tupaia*', *ibid.*, 1925, p. 559.

[3] 'The Anatomy of *Tarsius Spectrum*', *Proc. Zool. Soc. London*, 1925, p. 1071.

and Lemuroids, not directly associated with such habits, that can be interpreted only as evidences of affinity.

The Neopallium and its Relation to the Ability of Learning by Experience.

Having now sketched the broad lines of Man's pedigree right back to the most primitive mammals, let us next consider the outstanding factors that determined the course of his ancestor's progressive evolution.

The class Mammalia, to which Man belongs, is distinguished in structure from all other vertebrates mainly by the high development of the brain, and, as regards the behaviour of its members, by the fact that they are able in immeasurably greater degree than all other animals, not excluding even birds, to profit by individual experience. The behaviour of most, or perhaps it would be more correct to say all, animals, however complex and nicely adapted to their circumstances it may seem, is essentially instinctive; and the main problem we have to solve, in attempting to explain the emergence of the distinctive attributes of the creature that in greater measure than any other has succeeded in subordinating its instincts to reason, is the means by which it has become possible for the effects of individual experience to be brought to bear upon conduct.

The ability to learn by experience necessarily implies the development, somewhere in the brain, of a something that can act not only as a receptive organ for impressions of the senses and a means for enabling their influence to find expression in modifying behaviour, but also serve in a sense as a recording apparatus for storing such impressions, so that they may be revived in memory at some future time in association with other impressions received simultaneously, the state of consciousness they evoked, and the response they called forth.

Such an organ of associative memory is actually found in the brain of mammals. It is the cortical area for the exact designation of which I invented the term 'neopallium'.[1] Into it pathways lead from all the sense organs; and each of its territories that receives a definite kind of stimulus, visual, acoustic, tactile, or any other, is linked by the most intimate bonds with all the others. In spite of the disapproval of some psychologists, we can indeed regard the neopallium as fulfilling all the conditions of the *sensorium commune*, which Aristotle and many generations of philosophers have sought during more than twenty centuries; for it is unquestionably a 'unitary organ the physical processes of which might be regarded as corresponding to the unity of consciousness' (Wm. MacDougall).

Nothing that happens in this area in the course of its enormous expansion and differentiation in the higher mammals materially affects the fundamental purpose of the neopallium, which never loses its distinctive quality as a unifying organ that acts as a whole, though each part is favourably placed to receive and transmit to the rest its special quota to the sum total of what we may call the materials of conscious life.

The power of discrimination that resides, so to speak, in this neopallium, and is fed by the continual stream of sensory impressions pouring into it, which awaken memories of past experiences, can express itself directly in the behaviour of the animal through the intermediation of a part of the neopallium itself, the so-called motor area. That area is not only kept in intimate relation with the muscles, tendons, and skin by sensory impressions, but controls the voluntary

[1] 'The Natural Subdivision of the Cerebral Hemisphere', *Journ. Anat. and Phys.*, vol. xxxv, 1901, p. 431; Arris and Gale Lectures on the Evolution of the Brain, *Lancet*, 15 January 1910, p. 153. The problem of the origin of the neopallium I have discussed in 'A Preliminary Note on the Morphology of the Corpus Striatum and the Origin of the Neopallium' (*Journ. Anat.*, 1919, p. 271) and the claim that it was the essential factor in bringing the mammals into being in 'The Origin of Mammals' (*British Association Report*, 1911, p. 424).

responses of the muscles of the opposite side of the body.

In the animal kingdom progress is based essentially upon the attainment of more efficient and rapid means of locomotion and muscular skill. The primary advantage of a vertebrate over an invertebrate animal (leaving out of account the small and highly specialized insects) is the rapidity and precision of its movements. When a fish-like vertebrate emerged from the

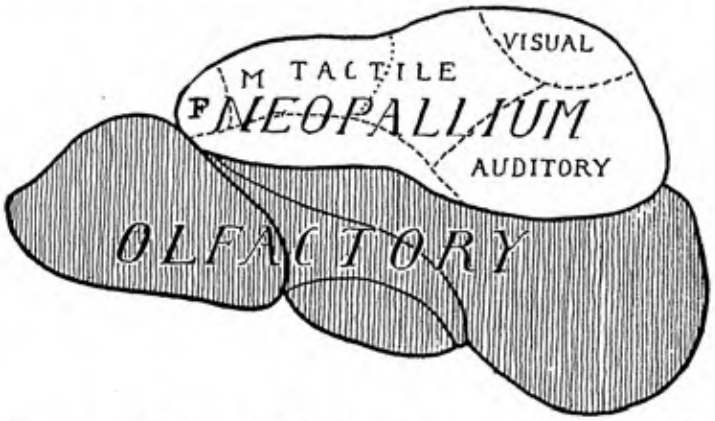

FIGURE 7. Diagram of the lateral aspect of the left cerebral hemisphere of a primitive mammal (the Jumping Shrew, *Macroscelides*) to show the relatively enormous extent of the primitive olfactory territories and the small neopallium with its receptive areas for tactile, visual, and auditory impressions. The anterior part of the tactile area (from *M* back to the dotted line) represents the so-called 'motor area'. *F* represents the rudiment of the frontal area.

water it had to acquire a new mode of locomotion, and the movements of the Amphibia upon land were slow and clumsy. The attainment of greater skill and rapidity marked the transformation of a primitive Amphibian (Stegocephalian) into a reptile, the modification of the limbs being effected *pari passu* with changes in the brain that made more efficient limbs biologically useful. Two groups of modified reptiles attained infinitely greater skill and quickness than their more conservative relatives: these developed into

birds and mammals, both characterized by greater skill and quickness, and especially by their ability to learn by experience.

Perhaps it would help the reader to get a wider vision of the significance of these facts if I refer briefly to certain general considerations. Man is a mammal; and this term implies a good deal more than the mere fact that human mothers feed their infants with milk secreted by specially modified skin glands. It means also that Man belongs to the great group of vertebrate animals equipped with hair and complex arrangements for maintaining a uniform body temperature. But above all this group is distinguished by the presence in the brain of a newly evolved area of cerebral cortex, the neopallium, in virtue of the possession of which the power of associative memory, that is, the ability to learn from individual experience, is enormously enhanced, and in particular the possibility is created of acquiring muscular skill.

The Mammalia were derived from a group of primitive reptiles called by Dr. Robert Broom the Therapsida, whose fossilized remains have been discovered in South Africa. The Therapsida are members of the primitive Theriodont reptiles which in the very distant past, in Triassic times, had an extensive geographical distribution, ranging from South Africa to America. I refer to these questions of palaeontology to call attention to the interesting suggestion made fifteen years ago by Dr. Broom that the South African Theriodonts from which mammals were derived became distinguished from their American allies by the fuller development of the functions of the limbs. According to him it was the lengthening of the limbs that led to the emergence of mammals. When the Therapsid took to walking with its feet underneath and its body off the ground it first became possible for it to become a warm-blooded animal. All the characters that distinguish a mammal from a reptile are the result of increased activity—the soft flexible

skin equipped with hair, the more freely movable jaws, the perfect four-chambered heart, and the hot blood. Mammals were brought into being as the result of the attainment of greater muscular skill. This skill was the direct result of the evolution of the neopallium. The increased control of the limbs enabled the early mammal to raise its body from the ground; and the development of hair (as in the parallel case of feathers in birds) helped at first in the maintenance of the uniformly warm temperature that became possible. The skin underwent a transformation in structure, and became the instrument of higher powers of tactile discrimination which the development of an extensive tactile representation in the neopallium made possible. The maintenance of the temperature of the skin at a uniform warmth added enormously to the delicacy of tactile discrimination, and in fact of every kind of cutaneous sensibility—touch, pressure, heat and cold, pain and sense of position and contrast.

In 1911 (*Proceedings of the British Association for the Advancement of Science*, p. 427) I summed up the argument in the following paragraphs, which I quote now because fifteen years of further study has confirmed their essential accuracy.

Dr. Broom was unable to offer any explanation of the lengthening of the limbs to which he assigned such revolutionary changes in structure and function.

But the fact that the lengthening in the limbs occurred coincidently with the emergence of the neopallium, the cerebral instrument that made the attainment of muscular skill possible, is surely more than a mere coincidence. The development of a definite neopallium, the lengthening of the limbs, the increased activity, the freeing of the skin of its mail-like coat of scales and its conversion into a highly developed organ of tactile discrimination—all these events happened at about the same time, and had a reciprocal influence one upon the other.

The evolution of the neopallium depended primarily

upon the increasing importance of the skin as an organ of discrimination: but this made possible the more efficient and direct control of skilled movements by the new cortical area that received completer information from the skin. The direct connexion of the neopallium with the motor nuclei and with the cerebellum reveals the fact that a new instrument for effecting rapid and more skilful movements had come into being. Mammals are adaptable and capable of learning rapidly from experience because they possess a neopallium—which is both an organ of associative memory and of rapid action.

I have referred to these problems to focus attention upon the consideration that the attainment of skill in movement and the acquisition of the knowledge which comes from the experience in the practice of such skill represent the fundamental factors of progress and adaptability to changing circumstances. Man eventually emerged in virtue of his transcendent powers of skilful achievement and the understanding acquired from cultivating his skill. His love of games is an expression of the innate aptitudes that brought his ancestors to man's estate. But the forms these games assumed—their rules and regulations and the spirit of sportsmanship that inspire them—are the results of tradition and a long chain of historical circumstances. The transference to the neopallium of the direct control of movements that previously had been regulated by the mid-brain represented merely the beginning of the process of building up a very complexly co-ordinated mechanism in the cerebral cortex for the attainment of skill. Later in this volume I shall have to return to the consideration of this process and all that it involves for the development of intelligence.

But before passing to the discussion of the evolution of the brain in Man's mammalian ancestors I must mention again the outstanding significance of the new cortical area that conferred upon mammals their adaptability and aptitude for progressive achievement.

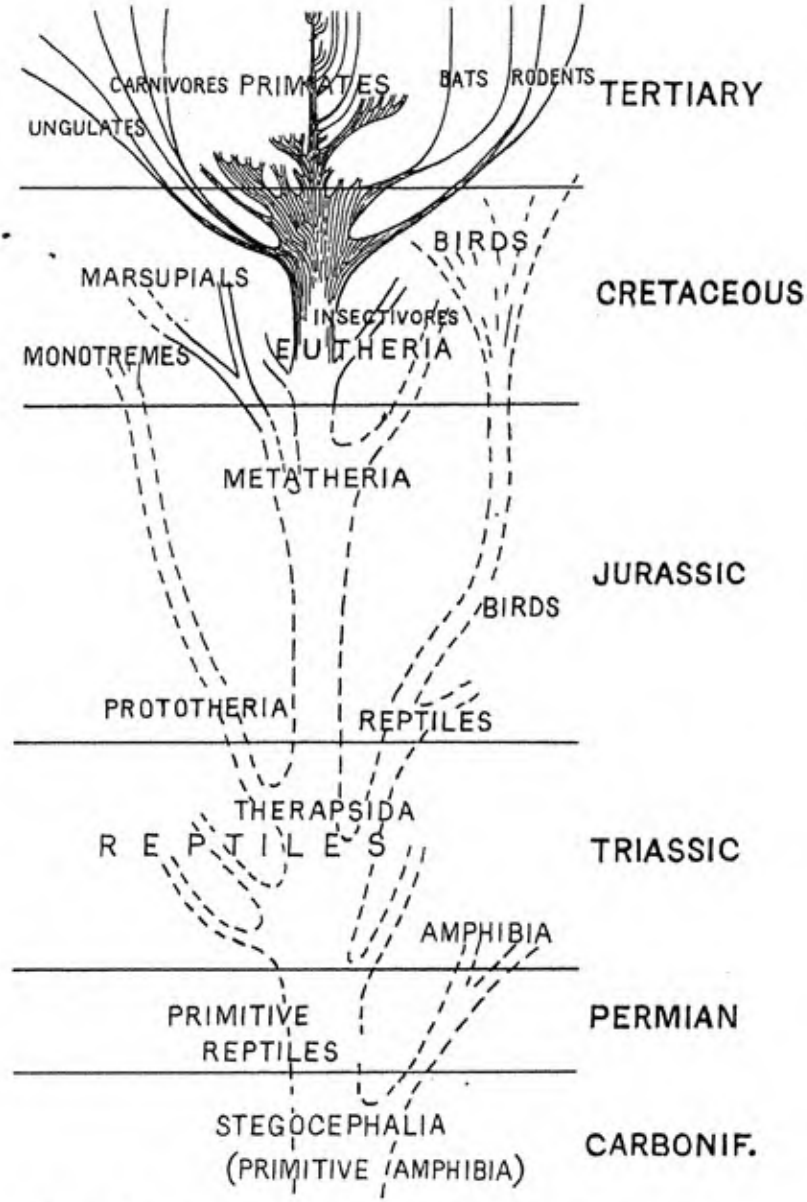

FIGURE 8. A tentative scheme of the relationships of the Primates (compare Fig. 2, p. 3) and other Mammals to Reptiles (Therapsida) and Amphibia (Stegocephalia).

The neopallium is the repository of past impressions and the instrument that makes it possible to compare a new experience with what has happened before and to modify behaviour in the light of such knowledge. In Man, as Dr. Henry Head has so lucidly explained,[1] other functions of the neopallium in sensation are to endow the latter with spatial relationships (to refer the sources of visual, auditory, and tactile stimuli to definite positions in space), with the power of responding in a graduated manner to stimuli of different intensities, and with those qualities by which we recognize the similarity or difference of objects that appeal to our senses.

The Differentiation of Mammals and the Effects of Specialization.

The possession of this higher type of brain enormously widened the scope for the conscious and intelligent adaptation of the animal to varying surroundings. The exercise of this newly acquired power of discrimination and ability to learn from individual experience enabled it to appreciate the possibilities of fresh sources of food supply and new modes of life. The way was opened for an infinite series of rapid adaptations to varying environments, entailing structural modifications in which the enhanced plasticity of the new type of animal found expression.

Nature tried innumerable experiments with the new type of brain almost as soon as the humble Therapsid-[2] like mammal felt the impetus of its new-found power of adaptation. In turn the Prototherian and Metatherian types of brain were tried before the more adaptable scheme of the Eutherian brain was evolved.[3]

[1] 'Sensation and the Cerebral Cortex', *Brain*, 1918.

[2] The primitive reptilian ancestors of the mammals, whose fossilized remains are found in South Africa.

[3] The Prototheria are the Monotremata (the Duck-billed Platypus and the Spiny Ant-eater), the most primitive living mammals. The Metatheria are the Marsupials (Kangaroos, Opossums, &c.), another

The new breed of intelligent creatures rapidly spread throughout the whole world and exploited every mode of livelihood. The power of adaptation to the particular kind of life each group chose to pursue soon came to be expressed in a bewildering variety of specializations in structure, some for living on the earth or burrowing in it, others for living in trees or even for flight; others, again, for an aquatic existence. Some mammals became fleet of foot and developed limbs specially adapted to enhance their powers of rapid movement. They attained an early pre-eminence and were able to grow to large dimensions in the slow-moving world at the dawn of the Age of Mammals. Others developed limbs specially adapted for swift attack and habits of stealth successfully to prey upon their defenceless relatives.

Most of these groups attained the immediate success that often follows upon early specialization. But they also paid the inevitable penalty. They became definitely committed to one particular kind of life, and in so doing they sacrificed their primitive simplicity and plasticity of structure, and in great measure also their adaptability to new conditions. The retention of primitive characters, which so many writers upon biological subjects, and especially upon anthropology, assume to be a sign of degradation, is not really an indication of lowliness. We should rather look upon high specialization of limbs and the narrowing of the manner of living to one particular groove as confessions of weakness, the renunciation of a wider life for one more sharply circumscribed.

The stock from which Man eventually emerged played a very humble role for long ages after many other Mammalian Orders had waxed great and strong. But the race is not always to the swift. The lowly group of mammals that took advantage of its insignificance to develop its powers evenly and very

Order of primitive mammals but more nearly akin to the higher mammals or Eutheria.

gradually without sacrificing in narrow specialization any of its possibilities of future achievement, eventually gave birth to the most dominant and most intelligent of all living creatures.

The Tree Shrews (Tupaiidae) are small squirrel-like animals which feed on 'insects and fruit, which they usually seek in trees, but also occasionally on the ground. When feeding, they often sit on their haunches, holding the food, after the manner of squirrels, in their fore paws.'[1] They are of 'lively disposition and great agility'.[2] These vivacious large-brained little Insectivores, linked by manifold bonds of relationship to some of the lowliest and most primitive mammals, present in the structure of their skull, teeth, and limbs, undoubted evidence of kinship, remote though none the less sure,[3] with their compatriots the Malaysian Lemuroids, and it is singularly fortunate for us in this inquiry that side by side there should have been preserved from a remote period before the Tertiary Period these Insectivores, which had almost become Primates, and a little primitive Primate, the Spectral Tarsier, which had almost (but not quite) assumed the characters of a true Monkey, when Nature fixed their types and preserved them throughout the ages, with relatively slight change, for us to study at the present day.

Thus we are able to investigate the influence of an arboreal mode of life in promoting the progressive development of a primitive mammal, and to appreciate precisely what changes were necessary to convert the lively, agile *Tupaia*-like ancestor of the Primates into a real Primate.

In the forerunners of the Mammalia the cerebral

[1] Flower and Lydekker, *Mammals, Living and Extinct*, 1891, p. 618.

[2] W. K. Gregory, *op. cit.*, p. 269, and pp. 279, 280.

[3] W. E. Le Gros Clark (*Proc. Zool. Soc. London*, 1925, p. 567) expresses the view that *Tupaia* is a representative of a very generalized group of Insectivorous mammals which was an offshoot from the stem of the Primate phylum after the latter had become definitely differentiated from other mammalian phyla.

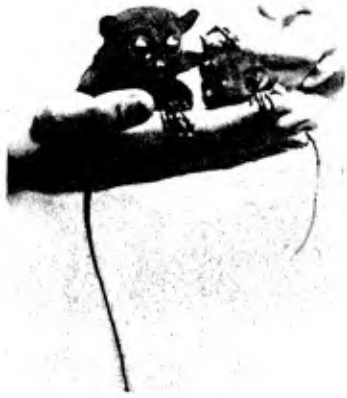

FIGURE 9

Spectral Tarsier (*Tarsius*), from Sarawak, Borneo.
A full-grown female and her infant seated on a human hand.
(*From a photograph lent by Mr. W. E. Le Gros Clark, F.R.C.S.*)

FIGURE 10

Tree Shrew (*Tupaia*), from Sarawak.
(*From a photograph lent by Mr. W. E. Le Gros Clark, F.R.C.S.*)

hemisphere was predominantly olfactory in function, and even when the true mammal emerged and all the other senses received due representation in the neopallium the animal's behaviour was still influenced to a much greater extent by smell impressions than by those of the other senses. This was due not only to the fact that the sense of smell had already installed its instruments in and taken possession, so to speak, of the cerebral hemisphere long before the advent in this dominant part of the brain of any adequate representation of the other senses, but also, and chiefly, because to a small land-grubbing animal the guidance of smell impressions, whether in the search for food or as a means of recognition of friends or enemies, sexual mates or rivals, was much more serviceable than all the other senses. Thus the small creature's mental life was lived essentially in an atmosphere of odours; and every object in the outside world was judged primarily and predominantly by its scent. The senses of touch, vision, and hearing were merely auxiliary to the compelling influence of smell.

Once such a creature left the ground and took to an arboreal life all this was changed; for the guidance of the olfactory sense lost much of its usefulness. Life amidst the branches of trees limits the usefulness of olfactory organs; but it is favourable to the high development of vision, touch, and hearing. Moreover, it demands an agility and quickness of movement that necessitates an efficient motor cortex to control and co-ordinate such actions as an arboreal mode of life demands (and secures, by the survival only of those so fitted) and also a well-developed muscular sensitivity to enable such acts to be carried out with precision and quickness. In the struggle for existence, therefore, some arboreal mammals, such as the Tree Shrews, suffer a marked diminution of their olfactory apparatus and develop a considerable neopallium, in which relatively large areas are given up to visual, tactile, acoustic, kinaesthetic, and motor functions, as well as to the purpose of providing a mechanism for

mutually blending in consciousness the effects of the impressions pouring in through the avenues of the different senses. It is only in *Tupaia* and the Primates, however, that these tendencies attain any really significant expression.

Thus a more equable balance of the representation of the senses is brought about in the large brain of the Tree Shrew, and its mode of life encourages and makes indispensable the acquisition of agility. Moreover, these modifications did not interfere in the case of the Tree Shrew with the primitive characters of limb and body. These small arboreal creatures were thus free to develop their brains and retain all the plasticity of a generalized structure, which eventually enabled them to go so far in the process of adaptation to almost any circumstances that presented themselves.

Amongst the members of this group, as in all the other mammalian phyla, the potency of the forces of natural selection was immensely enhanced by the fact that the inquisitiveness of an animal which can learn by experience—i. e. is endowed with intelligence—was leading these adaptable Insectivores into all kinds of situations that were favourable for the operation of selection. Various members of the group became specialized in different ways. Of such specialized strains the one of chief interest to us is that in which the sense of vision became especially sharpened.

The Origin of Primates.

Towards the close of the Cretaceous Period some small arboreal Shrew-like creature took another step in advance, which was fraught with the most far-reaching consequences. For it marked the birth of the Primates and the definite branching off from the other mammals of the line of Man's ancestry. Thus the most primitive of the Prosimiae came into being. The much-modified surviving representatives of this stage are the Lemurs, Galagos, and Lorises that are living

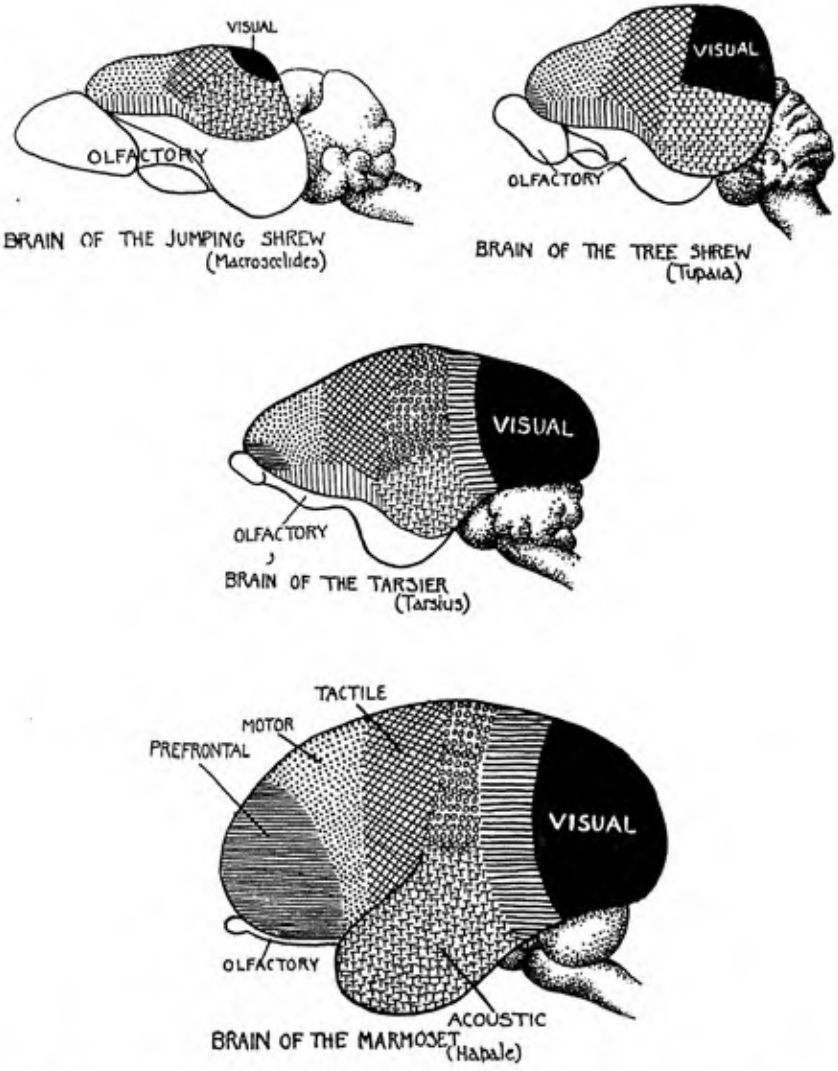

FIGURE 11. Diagrams representing the left side of the brains of the Menotyphlous Insectivores *Macroscelides* (the Jumping Shrew) and *Tupaia* (the Tree Shrew) (to illustrate the influence of change of habit in two members of the same Family), and of the Spectral Tarsier (*Tarsius*), the Prosimian, which had almost become a true Monkey, and of the Marmoset (*Hapale*), the most primitive surviving Monkey.

to-day in Madagascar, Africa, and south-eastern Asia respectively.

A noteworthy further reduction in the size of the olfactory parts of the brain, such as is seen in that of *Tarsius*,[1] quite emancipated the creature from the dominating influence of olfactory impressions, the sway of which was already shaken, but not quite overcome, in the Tupaioid and Lemuroid phases of its ancestry. This change was associated with an enormous development of the visual cortex in the neopallium, which not only increased in extent so as far to exceed that of the Lemurs, but also became more highly specialized in structure.[2] Thus, in *Tarsius*, vision entirely usurped the controlling place once occupied by smell; but the significance of this change is not to be measured merely as the substitution of one sense for another. The visual area of cortex, unlike the olfactory, is part of the neopallium (Fig 7); and when its importance thus became enhanced the whole of the neopallium felt the influence of the changed conditions. The sense of touch also shared in the effects, for tactile impressions and the related kinaesthetic sensibility, the importance of which to an agile tree-living animal is obvious, assist vision in the conscious appreciation of the nature and the various properties of the things seen, and in learning to perform agile actions which are guided by vision.

An arboreal life also added to the importance of the sense of hearing; and the cortical representation of this sense exhibits a noteworthy increase in the Primates, the significance of which it would be difficult to exaggerate in the later stages, when the simian are giving place to the distinctively human characteristics.

Increased reliance upon the guidance of the sense of sight awakened in the creature the curiosity to examine the objects around it with closer minuteness and supplied

[1] 'On the Morphology of the Brain in the Mammalia, with special reference to that of the Lemurs, Recent and Extinct', *Trans. Linn. Soc. Lond.*, second series; *Zoology*, vol. viii, part 10, February, 1903.

[2] Dr. H. H. Woollard has given an account of the cerebral cortex of *Tarsius* in the *Journal of Anatomy*, 1925.

guidance to the hands in executing more precise and more skilled movements than the Tree Shrew attempts. Such habits not only promoted the development of the motor cortex itself, and cultivated the discriminative powers of the tactile and kinaesthetic senses, but they linked up their cortical areas in bonds of more intimate associations with the visual cortex.

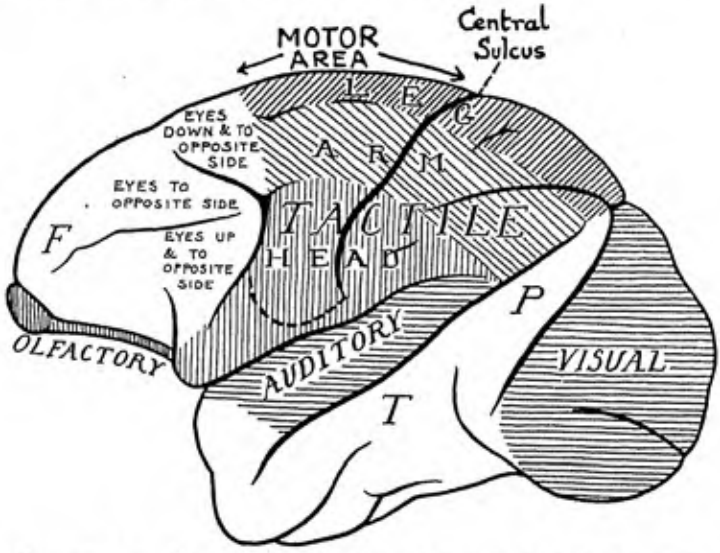

FIGURE 12. Diagram of the lateral aspect of the left cerebral hemisphere of a Monkey (Macaque) to show the extent of the visual, tactile (including the motor), and auditory receptive centres, and the new areas (parietal, *P*, temporal, *T*, and prefrontal, *F*) the progressive development of which is the fundamental factor in the emergence of the distinctive attributes of mankind.

The motor area itself is merely the modified anterior part of the tactile area (Fig. 12), as much of it as is in front of the central sulcus. Throughout the vertebrate series muscular activity is invariably under the supreme control of the ultimate central terminus of the nerves of touch. When these sensory pathways lead to the mid-brain this exercises a direct control over the animal's movements. When the terminus is transferred from the mid-brain to the cerebral hemisphere (neopal-

lium) the tactile area of cortex acquires a direct influence over voluntary muscular actions. But with the increased aptitude to acquire skill in movement there is an expansion and differentiation not only of the cortical area concerned with tactile discrimination, but also of the cortical machinery for controlling the executive processes involved in the acquisition of skill. The growth and differentiation of the tactile area, both in front and behind the central sulcus (Fig. 12), leads not only to a noteworthy extension of the cortical territory that is in direct communication with the sensory and motor nerve-paths; but in addition new formations grow out—backwards to add to the parietal area, *P*, and forwards to form the prefrontal area, *F*.

The process of devising the complex machinery for controlling skilled movements leads to the progressive development of the prefrontal territory, the size of which becomes a distinctive feature of the Primates, and in particular of Monkeys, Apes, and Men (see Fig. 11). In the lowlier mammals stimulation of the diminutive prefrontal area (Fig. 7, *F*) provokes movements of the head and the eyes (or at first only of the eye of the opposite side of the body). When a true Monkey evolves from a Tarsioid and the prefrontal territory suddenly attains a noteworthy increase in extent, electrical stimulation of this area (in the places indicated in Fig. 12) produces a wide range of closely co-ordinated movements of the two eyes. These conjugate movements, and in particular the acts of convergence, are the necessary preliminaries for fixing the visual attention upon an object to be studied. Moreover, they are obviously also an essential part of the process involved in guiding the hands to learn to perform skilful actions. The prefrontal area is thus intimately concerned not only with the acquisition of skill, but also with controlling the automatic movements of the eyes, which are an essential part of the process of fixing the gaze and concentrating the attention upon some object. The purpose of such a psychological process is to make further

observations or to extend the range of thought. The prefrontal area is thus a necessary part of the apparatus concerned with the process of learning and thinking. Such an organ co-ordinated the activities of the whole neopallium so as the more efficiently to regulate the various centres controlling the muscles of the whole body. In this way not only is the guidance of all the senses secured, but the way opened for all the muscles of the body to act harmoniously so as to permit the concentration of their action for the performance of delicate and finely adjusted movement.

In some such way as this there was evolved from the motor area itself, in the form of an outgrowth placed at first immediately in front of it, a formation that attains much larger dimensions and a greater specialization of structure in the Primates than in any other Order. It is the germ of the great prefrontal area of the human brain, which is said to be 'concerned with attention and the general orderly co-ordination of psychic processes'.[1] This area, in far greater measure than any other part of the brain, deserves of being regarded as the seat of the higher mental faculties and the crowning glory and distinction of the human fabric.

But the cortical developments adumbrated in the last paragraphs could not take place until the range of conjugate movements of the eyes was considerably extended. This did not happen in *Tarsius*: but when some Eocene Tarsioid acquired the ability to move its two eyes in any direction in intimate correlation the one with the other a new impulse was given to cortical development and true Monkeys came into being. The essential factor in this profound transformation was the evolution in the prefrontal area of the mechanism for making possible a wider range of conjugate movements of the eyes (Fig. 12). The fuller consideration of this will be taken up in Chapter III.

By means of the land connexions during Tertiary

[1] J. S. Bolton, 'The Functions of the Frontal Lobes', *Brain*, 1903.

times, the Eocene series of which are shown in Fig. 6, Man's ancestors were able to wander from continent to continent until they completed the circuit of the globe: at each stage in the migrations of menotyphlous, prosimian, platyrrhine, catarrhine, and anthropoid forerunners, the unprogressive members tended to remain in the neighbourhood of the home of their immediate ancestors, whereas those that wandered into new surroundings had to struggle for their footing, and by this striving attained a higher rank. In other words, they had to adapt themselves to new conditions, and those that failed to do so did not survive.

In the series of Primates there was a steady development of the brain—expansion and differentiation of the visual, tactile, and auditory centres, and development of the motor areas, and the power of skilled movements, especially of the hands and fingers; and a progressive expansion of the prefrontal area—along the lines marked out once for all when the first Primate was formed from some menotyphlous progenitor.

Thus the outstanding feature in the evolution of the Primate brain was a steady growth and differentiation of precisely those cortical areas that took on an enhanced importance in the earliest Primates.[1]

In the brain of the Gorilla (Fig. 13) a form and a structure that seem to foreshadow the distinctively human type of brain are clearly revealed. All the cortical formations found in the brain of Man are represented, although the parietal (*P*), temporal (*T*), and prefrontal (*F*) areas are significantly smaller.

The germs of Man's intellectual pre-eminence were sown at the very dawn of the Tertiary Period, when the first Anaptomorphid[2] began to rely upon vision rather than smell as its guiding sense. In all the

[1] For the chief work on the Gorilla's brain see Leyton and Sherrington, 'The Excitable Cortex of the Chimpanzee, Orang-Utan, and Gorilla', *Quart. Journ. Experimental Physiology*, vol. xi, 1917, p. 135.

[2] Fossil Tarsioid of the Eocene Period.

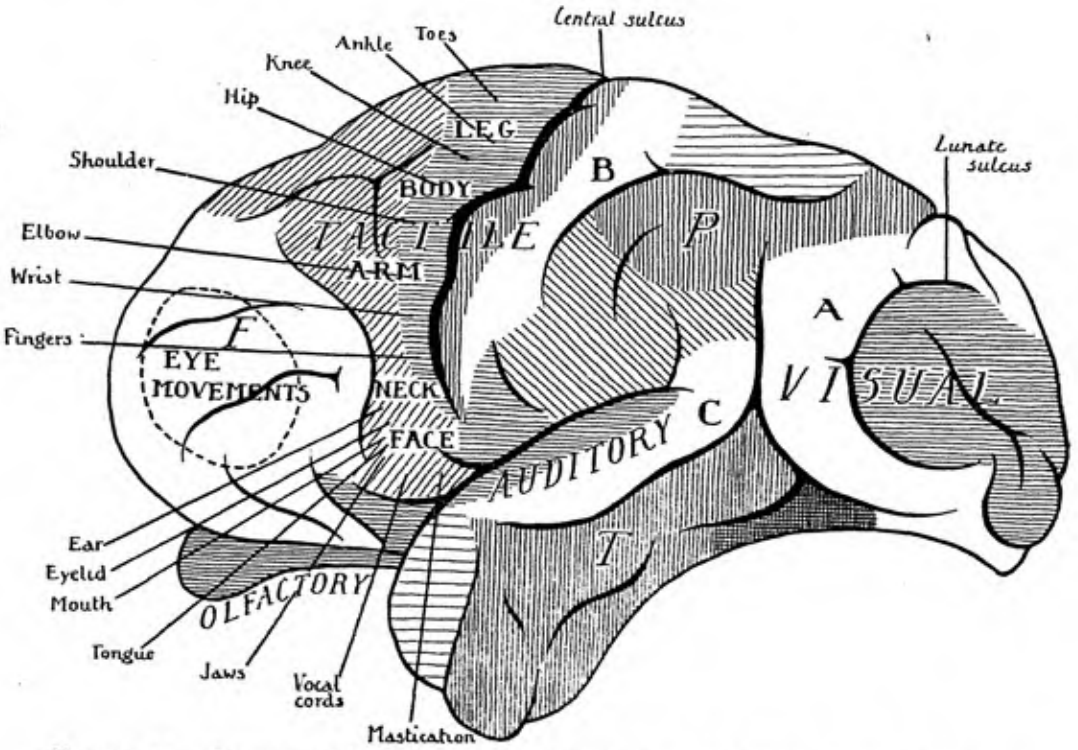

FIGURE 13. Diagram of the lateral aspect of the left cerebral hemisphere of a Gorilla. The so-called motor area, the part of the tactile area in front of the central sulcus, is labelled with the names of the parts of the body the movements of which each of them controls.

succeeding ages the fuller cultivation of the means of profiting by experience, which the Tarsioid had adopted, led to the steady upward progression of the Primates. From time to time many individuals, finding themselves amidst surroundings that were thoroughly congenial and called for no effort, lagged behind; and in the Lemurs and *Tarsius*, the New World Monkeys, the Old World Monkeys, and the Anthropoid Apes we find preserved a series of these laggards that turned aside from the highway which led to Man's estate.

The Primates at first were a small and humble folk, who led a quiet life, unobtrusive and safe in the branches of trees, taking small part in the fierce competition for size and supremacy that was being waged upon the earth beneath them by their carnivorous, ungulate, and other brethren. But all the time they were cultivating the equable development of all their senses and limbs, and the special development of the more intellectually useful faculties of the mind that, in the long run, were to make them the progenitors of the dominant mammal —the mammal destined to obtain the supremacy over all others, while still retaining much of the primitive structure of limb that his competitors had sacrificed. It is important, then, to keep in mind the fact that the retention of primitive characters is often to be looked upon as a token that their possessor has not been compelled to turn aside from the straight path and adopt protective specializations, but has been able to preserve some of the plasticity associated with his primitiveness, precisely because he has not succumbed or fallen away in the struggle for supremacy. It is the wider triumph of the individual who specializes late, after benefiting by the many-sided experience of early life, over him who in youth becomes tied to one narrow calling.

In many respects Man retains more of the primitive characteristics—for example, in his hands—than his nearest simian relatives; and in the Nordic and Alpine races of mankind many traits, such as abundance of hair, persist to suggest pithecoid affinities that have

been lost by the more specialized Negro and other races, but survive in the more generalized Aboriginal Australian. Those anthropologists who use the retention of primitive features in the European as an argument to exalt the Negro to equality with him are neglecting the clear teaching of comparative anatomy, that the persistence of primitive traits is often a sign of strength rather than of weakness. This factor runs through the history of the whole animal kingdom.[1] Man is the ultimate product of the line of ancestry that was never compelled to turn aside and adopt protective specialization, either of structure or mode of life, which would be fatal to its plasticity and power of further development.

The Struggle for Dominance between Smell and Vision.

Before we can form any adequate appreciation of the far-reaching influence of visual dominance in the Primates it is necessary to emphasize certain general considerations to explain why enhancement of visual control in a mammal, which is an animal provided with a true neopallium, differs so profoundly in its effects from a similar event in a fish, a reptile, or even a bird.

In the vast majority of living animals behaviour is dominated either by smell or vision. Of these smell is the more primitive and fundamental factor. The cerebral cortex was evolved from that part of the brain which originally was little more than the receptive centre for impressions of smell and the instrument for enabling the sense of smell to influence the animal's behaviour. Unlike all the other sensory tracts, those which convey impulses from the olfactory organ reach the cerebral cortex directly—that is, without passing through the thalamus. From a psychological point of view, therefore, the sense of smell occupies a unique

[1] 'The Brain in the Edentata', *Trans. Linn. Soc.*, 1899.

and distinctive position. It represents the germ of all the higher psychical powers, or, perhaps it would be more accurate to say, the cement that binds together the elements out of which the powers of the cerebral cortex, as the repository of the impressions of past experiences, the organ of discrimination and appreciation of space and time, are developed.

In the primitive vertebrate behaviour is controlled mainly by the sense of smell. It is the means by which the animal finds its food and determines its qualities, by which it recognizes friends or enemies, sexual mates or rivals. Smell is possessed of affective qualities that endow it with a direct meaning such as is not associated with either of the other two 'distance receptors' (Sherrington), vision and the eighth nerve sense, which in the terrestrial vertebrates is acoustic. All that vision implies to the primitive vertebrate is light or darkness, movement and stillness. It conveys no real knowledge of food or the animal's vital interests. In the primitive vertebrate living in the water smell is much more nearly akin to taste than it is in Man and the land-living animals. When such an animal perceives the odour of food it is really getting a foretaste of the consummation of the reaction when it captures the food and actually tastes it. Throughout the whole of the anticipatory phase it is under the influence of olfactory sensations. A series of events, covering the whole period of anticipation and consummation, is linked together by the affective tone of smell into one experience, which includes the germ of memory and of spatial and temporal appreciation. Thus it confers upon experience the element of coherence. Without it the animal might have a series of isolated and momentary experiences of consciousness not linked together as a connected whole. Smell confers upon such a train of events the link that unites them and enables the animal to anticipate the consummation because it had previously been associated in the same experience with the anticipatory stimulus. It represents the germ of associative

memory, which we, under the domination of vision, usually call looking backward, and the ability to anticipate the consummation, looking forward.

But the sense of smell conveys only the vaguest indications of spatial relations. An animal attracted by a scent circles around it until it comes within visual range of its quarry: then the eyes convey more precise information as to its position in space and as to its movements. Such visual information is almost entirely devoid of affective tone, of psychological meaning, which it acquires secondarily from the sense of smell. This meaning is at first due to a sort of conditioned reflex of Pavlov, that in course of time has become transformed into a true reflex or instinct. For example, a Dog that is not fed until it responds to the ringing of a bell—an experience altogether outside the natural course of events and utterly irrelevant to the idea of food—learns to associate the ringing of the bell with the idea of food. The mere sound of the bell is sufficient to awaken the emotion of pleasure to stimulate the appetite and evoke such involuntary reactions as salivation. Pavlov would call the incident of the Dog's mouth 'watering' when a bell rings a conditioned reflex.

Similarly, when a teleostean fish relies upon information acquired by its eyes to find its prey (as in fly-fishing) instead of by smell as the primitive ancestral fish does, it is because the visual experience of food has become linked up with its smell and taste so as to confer upon the former the 'meaning' that is inherent in the latter. But in the case of the fish the conditioned reflex has become stereotyped and hereditarily transmitted. The guidance of vision is biologically useful, because it enables the creature to steer its course more directly and accurately to the object of the pursuit, and for this reason it is the optic receptive centre, the tectum of the mid-brain, which in the primitive vertebrate is put into direct connexion with the motor nuclei and directs the movements of the animal. The sense of smell starts the reaction, the sense of sight directs it (Fig. 14).

In the course of the pursuit of its prey, when the animal is impelled by the sense of smell and controlled by its dominating affective tone, the information collected by all the other sensory instruments is added to and woven into the tissue of the complex experience. Hence these other senses acquire a meaning and a share in the psychical activities that constantly increase in importance throughout the vertebrate series, until it culminates in the vast mental powers of Man, in which smell plays a humbler and less obtrusive part (compare, for example, Figs. 7 and 10), although still one of imperious importance, especially in matters that concern the appetites and sentiments.

I have emphasized this fundamental relationship of vision to smell because it is essential for the proper understanding of the respective roles of these dominant senses.[1] Moreover, Sir Charles Sherrington, to whose pioneer work we are indebted for a definition of these problems, has not given adequate recognition to the dependence of vision upon smell for the acquisition of the meaning of vital experience.

Discussing the vastness of the influence of the sense of smell in exciting instinctive reactions in both invertebrate and vertebrate animals, Professor W. Mitchell has expressed the opinion that:

> 'No sense originates more remarkable instincts than the sense of smell, and among lower animals there are certainly no instincts, whether individual or social, that are more indispensable. Yet no sensation is less fitted to represent a complex object . . . its very supersession by sight and sound (in man and the primates) is evidence of the instinctive and thoughtless character of the reactions upon it.'[2]

I need not deal with the significant part still played by smell in Man, in reviving memories of scenes and circumstances and in particular the emotional tone

[1] *The Integrative Action of the Nervous System*, p. 330.
[2] *Structure and Growth of the Mind*, 1907, pp. 126 and 127.

associated with such past experiences.[1] In the whole history of living animals, both invertebrate and vertebrate, there has been a constant rivalry between smell and vision for dominance. Behaviour in the primitive members of every group is controlled pre-eminently by smell, and invariably in the more efficient members of such groups vision has usurped the control, as in the teleostean fishes, in birds, and the highest mammals. But in all vertebrate classes excepting mammals visual dominance is attained only at the expense of a precocious specialization of the brain that is fatal to progress, or, at any rate, to the kind of advancement that leads

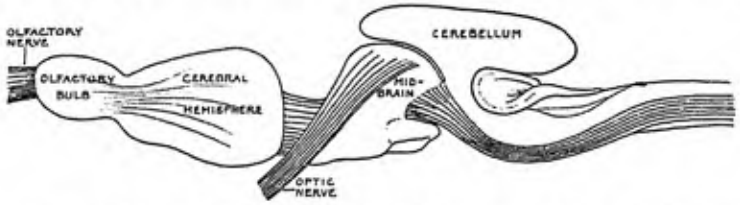

FIGURE 14. Diagram of Primitive Vertebrate Brain. The cerebral hemisphere is the receptive organ for the olfactory nerves; the mid-brain for the optic nerves. Motor path from mid-brain to spinal cord is not labelled.

towards the attainment of the human type of intelligence. In the brain of the primitive vertebrate the cerebral hemisphere is essentially the receptive instrument for olfactory impulses, whereas visual impulses are received mainly by the mid-brain. Hence a precocious increase of the influence of vision involves a development of the mid-brain at the expense of the fore-brain, and in that sense is fatal to the evolution of the brain in the direction of the enhancement of the functions of the cerebral cortex (Fig. 14).

It is only in mammals in which vision, so to speak, has secured representation in the cerebral cortex that fuller reliance on this sense does not involve an impair-

[1] This subject is discussed in an interesting way in Luciani's *Human Physiology*, vol. iv.

ment of the influence of the cerebral cortex. In mammals, in fact, the cultivation of vision acts as the most powerful stimulus to the growth and elaboration of the cerebral cortex and the progressive development of its psychological possibilities, because the receptive centre for impulses from the eyes is in the neopallium (compare Figs. 7, 11, 12, and 13).

The Origin of Man.

Having examined the nature of the factors that have made a Primate of an Insectivore, and transformed a Tarsioid Prosimian into an Ape, let us turn to consider how Man himself was fashioned.

It is the last stage in the evolution of Man that has always excited chief interest and has been the subject of much speculation.

These discussions usually resolve themselves into the consideration of such questions as whether it was the growth of the brain, the acquisition of the power of speech, or the assumption of the erect attitude that came first and transformed an Ape into a human being. The case for the erect attitude was ably put by Dr. Munro in 1893.[1] He argued that the liberation of the hands and the cultivation of their skill lay at the root of Man's mental supremacy.

If the erect attitude is to explain all, why did not the Gibbon become a man in Miocene times or earlier? The whole of my argument has aimed at demonstrating that it is the steady growth and specialization of the brain that has been the fundamental factor in leading Man's ancestors step by step upward from the lowly Insectivore status, and through every earlier phase (Amphibian and Reptilian) in the evolution of Mammals—for Man's brain represents the consummation of precisely those factors that throughout the Vertebrata have brought their possessors to the crest of the wave of progress. But such advances as the assumption of

[1] Presidential Address to Section H, *Report of the Brit. Assoc.*

the erect attitude are brought about because the brain has made a new posture and skilled movements of the hands possible and of definite use in the struggle for existence. Yet once such a stage has been attained, the very act of liberating the hands for the performance of more delicate movements opened the way for a farther advance in brain development to make the most of the more favourable conditions and the greater potentialities of the hands.

I have already referred to the fact that the adoption of vision as the dominant sense enhanced the functional importance of the neopallium, the dominant part of the nervous system, and, in fact, of the whole organism. It has been shown by Professor Magnus of Utrecht[1] that with the enhanced importance of vision the eyes come to play a significant part in regulating posture and muscle tone. This assumption by the cerebral cortex of automatic functions hitherto controlled mainly by lower centres brings the regulation of posture into closer relationship with the functions of the neopallium. Such a development becomes a factor of fundamental importance in establishing the erect attitude. I shall return to the discussion of this question in a later chapter.

It is a fact beyond dispute that the divergent specialization of the human limbs—one pair for progression and the other for prehension—and the more delicately adjusted skilled action, has played a large part in preparing the way for the emergence of the distinctly human characteristics; but it would be a fatal mistake unduly to magnify the influence of these developments. Such a primitive member of the Primates as the Spectral Tarsier can assume the erect attitude and use its hands for prehension rather than progression, and many other Lemurs, such as the Indrisinae of Madagascar, can and do walk erect.

In the remote Oligocene, a Catarrhine Monkey

[1] Croonian Lecture on Animal Posture, *Proc. Roy. Soc.*, B, 1925, p. 339.

became definitely modified in structure to become an Anthropoid Ape. It lost its tail and, in virtue of the progressive development of its brain, became more skilled and apt to learn. One of the manifestations of these new powers was a greater facility in walking in the erect attitude. This type of early Anthropoid has persisted with relatively slight modifications in the Gibbon of the present day. But if the earliest Gibbons were already able to walk upright, how is it, one might ask, that they did not begin to use their hands, thus freed from the work of progression on the earth, for skilled work, and at once become men? The obvious reason is that the brain had not yet attained a sufficiently high stage of development to provide skilled work, apart from the tree climbing, of biological usefulness for these competent hands to do.

The Ape is tied down absolutely to his experience, and has only a very limited ability to anticipate the results even of relatively simple actions, because so large a proportion (in comparison with that of Man) of his neopallium is under the dominating influence of the senses. Without a fuller appreciation of the consequences of its actions than the Gibbon is capable of, the animal is not competent to make full use of the skill it undoubtedly possesses. What is implied in acquiring this fuller appreciation of the meaning of events taking place around the animal? The state of consciousness awakened by a simple sensory stimulation is not merely an appreciation of the physical properties of the object that supplies the stimulus; the object simply serves to bring to consciousness the results of similar or contrasted experiences in the past, as well as the feelings aroused by or associated with them, and the acts such feelings excited. This mental enrichment of a mere sensation so that it acquires a very precise and complex meaning is possible only because the individual has this extensive experience to fall back upon; and the faculty of acquiring such experience implies the possession of large neopallial

FIGURE 15
An adult chimpanzee's attempt at standing erect.

areas for recording, so to speak, these sensation factors and the feelings associated with them. The 'meaning' which each creature can attach to a sensory impression presumably depends, not on its experience only, but more especially upon the neopallial provision in its brain for recording the fruits of past experience. The Anthropoid Apes are distinguished from the lowlier Primates and even more emphatically from other mammals by the relative rapidity with which they can learn and the complexity of the acts they are competent to acquire and in some measure understand. The behaviour of the Chimpanzee has recently been interpreted in a very interesting way by Professor Koehler in *The Mentality of Apes* and Professor Yerkes in *Almost Human*. The educability of the anthropoids can confidently be attributed to the relatively more extensive development of the neopallial territories (Fig. 13, *F*, *P*, and *T*) known in Flechsig's phraseology as 'association areas', i.e. parts of the cortex that do not receive sensory impressions directly but, so to speak, record, blend, and elaborate them.

Judged by this standard, the human brain bears ample witness, in the expansion of the great temporo-parietal area, which so obviously has been evolved from the regions that link together the visual, auditory, and tactile territories, to the perfection of the physical counterpart of the enrichment of mental structure, which is the fundamental characteristic of the human mind.

The second factor that came into operation in the evolution of the human brain is merely the culmination of a process which has been steadily operating throughout the Primates. I refer to the high state of perfection of the cortical regulation of skilled movements, many of which are acquired by each individual in response to a compelling instinct that forces every normal human being to work out his own salvation by perpetually striving to acquire such manual dexterity. In a sense the prefrontal expansion is an

index of the aptitude for acquiring such skill, although of course the parietal, temporal, and occipital areas of the brain play a part in the process of learning.

This brings us to the consideration of the nature of the factors that have led to the wide differentiation of Man from the Gorilla. Why is it that these two Primates, structurally so similar and derived simultaneously from common parents, should have become separated by such an enormous chasm, so far as their mental abilities are concerned?

There can be no doubt that this process of differentiation is of the same nature as those which led one branch of the Eocene Tarsioids to become Monkeys, while the other remained Prosimiae or, as the Germans express it, 'Half-Apes'; advanced one group of primitive Monkeys to the Catarrhine status, while the rest remained Platyrrhine; converted one division of the Old World Apes into Anthropoids, while the others retained their old status. Put into this form as an obvious truism, the conclusion is suggested that the changes which have taken place in the brain to convert an Ape into Man are of the same nature as, and may be looked upon merely as a continuation of, the processes of evolution that we have been examining in the lowlier members of the Primate series. It was not the adoption of the erect attitude that made Man from an Ape, but the gradual perfecting of the brain and the slow upbuilding of the mental structure, of which erectness of carriage is one of the incidental manifestations.

The ability to perform skilled movements is conducive to a marked enrichment of the mind's structure and the high development of the neopallium, which is the material expression of that enrichment. There are several reasons why this should be so. The mere process of learning to execute any act of skill necessarily involves the cultivation, not only of the muscles which produce the movement, and the cortical area which excites the actions of these muscles, but in even greater

measure the sensory mechanisms in the neopallium which are receiving impressions from the skin, the muscles, and the eyes, to control the movements at the moment, and incidentally are educating these cortical areas, stimulating their growth, and enriching the mental structure with new elements of experience. Out of the experience gained in constantly performing acts of skill the knowledge of cause and effect is eventually acquired. Thus the high specialization of the frontal area, which made complicated actions possible, and the great expansion of the temporo-parietal area, which enabled the Ape-Man to realize the 'meaning' of events occurring around him, reacted one upon the other, so that the creature came to understand how a particular act would entail certain consequences. In other words, it gradually acquired the faculty of shaping its conduct in anticipation of results.

Long ages ago, possibly in the Miocene (see Fig. 2), the ancestors common to Man, Gorilla, and Chimpanzee became separated into groups. The different conditions to which they became exposed after they parted company were in the main responsible for the contrasts in their fate. In one group the distinctively Primate process of growth and elaboration of the brain, which had been going on in their ancestors for many thousands, even millions, of years, reached a stage when the more venturesome members of the group—stimulated perhaps by some local failure of the customary food, or maybe led forth by a curiosity bred of their growing realization of the possibilities of the unknown world beyond the trees that hitherto had been their home—were impelled to issue forth from their forests, and seek new sources of food and new surroundings on hill and plain, wherever they could obtain the sustenance they needed. Perhaps the fossil Ape found in 1924 at Taungs in Bechuanaland reveals the earliest phase of this process of transformation, and emancipation from the necessity of living in trees. The other group, perhaps because they happened to be

more favourably situated or attuned to their surroundings, living in a land of plenty, which encouraged indolence in habit and stagnation of effort and growth, were free from this glorious unrest, and remained Apes, continuing to lead very much the same kind of life (as Gorillas and Chimpanzees) as their ancestors since the Miocene or even earlier times. That both these unenterprising relatives of Man happen to live in the forests of tropical Africa has always seemed to me to be a strong argument in favour of Darwin's view that Africa may have been the original home of the first creatures definitely committed to the human career; for while Man was evolved amidst the strife with adverse conditions, the ancestors of the Gorilla and Chimpanzee gave up the struggle for mental supremacy because they were satisfied with their circumstances; and it is more likely than not that they did not change their habitat.

The Taungs Ape.

The fossilized skull of a hitherto unknown type of Man-like Ape (Fig. 4) was discovered in a pocket in the limestone (50 feet below the surface and 200 feet from the original edge of the cliff) at Taungs in Bechuanaland in November 1924, by workmen of the Northern Lime Company.

The discovery is exceptionally important and interesting. For the first time the whole face and a cast of the brain-case of a fossil Man-like Ape were revealed. Moreover, the Taungs Ape was found in a place hundreds of miles distant from the domain of the Gorilla and Chimpanzee, and in a region where forest conditions such as are essential to these other Anthropoid Apes seem to have been lacking. More important still, this Ape, which like Man may have been emancipated from the necessity of living in forests, seems to reveal definite evidence of nearer kinship with Man's ancestors than any other Ape presents.

The discovery has the additional interest in that it

affords a striking confirmation of Darwin's prediction (*Descent of Man*, 1871) that 'Africa was formerly inhabited by extinct Apes closely allied to the Gorilla and Chimpanzee', from which he drew the further inference that, 'as these African Apes present the nearest likeness to Man in structure and ability', it is somewhat more probable that our early progenitors lived on the African continent than elsewhere'.

The circumstances of the discovery are briefly as follows. When Dr. Raymond A. Dart went out to the University of the Witwatersrand as Professor of Anatomy he took with him from University College, London, a series of casts of the brain-cases of Apes and extinct members of the Human Family. With the help of these he interested his students and colleagues in the problems of Man's origin, and instituted a search for fossils and other anthropological data in various places in South Africa. As the result of the interest so aroused one of his student demonstrators, Miss Josephine Salmons, borrowed from Mr. E. G. Izod (of the Rand Mines Limited) the skull of a fossil Monkey found at Taungs, and brought it to Professor Dart for examination. He consulted his colleague, Dr. R. B. Young, the Professor of Geology in the University of the Witwatersrand, who happened to be studying the lime deposits in a farm at Taungs adjoining the Northern Lime Company's works, the general manager of which, Mr. A. F. Campbell, allowed him to examine the place where Mr. Izod's fossil was obtained. Professor Young found some rock fragments disclosing bits of bone and also masses of stone that seemed to be natural casts of brain-cases, which he took back to Johannesburg for Professor Dart to examine. While manipulating the pieces of rock Professor Dart found that the largest natural cast of a brain-case fitted at its broken front end on to another piece of rock in which parts of the lower jaw were visible. After several months of highly skilful and delicate work Professor Dart was able to clear the whole of the face and to fit it on to

the cast of the brain-case so as to restore the general form of the whole head and face (Fig. 4). He then realized that the fossil was the remains of a hitherto unknown genus of Apes revealing interesting points of likeness to Man. He named it *Australopithecus Africanus*. As the jaws still retained the 'milk teeth' and the first permanent teeth had only just appeared, the Taungs Ape was at the stage of development corresponding to a six years old human infant or a Chimpanzee of three years or less.

It was a lucky chance that this endocranial cast came into the hands of Professor Dart, because he had been devoting himself (for several years at University College, London) to the investigation of such material, and had, in fact, created new species of fossil Zeuglodonts on the basis of natural casts of the brain-case.

Athough Professor Dart lacked opportunities for comparing his wonderful fossil with the crania of Anthropoids of a corresponding age and had no one with technical knowledge of such matters to consult, he showed conspicuous insight in arriving at the conclusion that *Australopithecus* was an Anthropoid Ape revealing definite signs, none the less significant because they are slight, of a reduction and refinement of the face and a development of the brain suggestive of the changes long believed on theoretical grounds to have been the first stage in the transformation of an Ape into a human being. These two changes—in face and brain—are displayed with diagrammatic clearness when a profile of the Taungs Ape is superimposed upon similar tracings of the skulls of a young Chimpanzee and a young Orang at a stage when (as in *Australopithecus*) the first permanent molar has erupted.

There are reasons for assuming that the climatic conditions at Taungs on the edge of the Kalahari Desert were not, when *Australopithecus* was alive, very different from what they are now. Hence the habits of this Ape must have been in sharp contrast to those of any of the living Anthropoids, who are more

or less tied down to forest conditions. If the inference is a just one, the emancipation from this restraint affords further corroboration of the unique characters and aptitudes of *Australopithecus*. But there is no evidence to suggest that its posture differed from that of the Chimpanzee. The peculiarity in the position of the

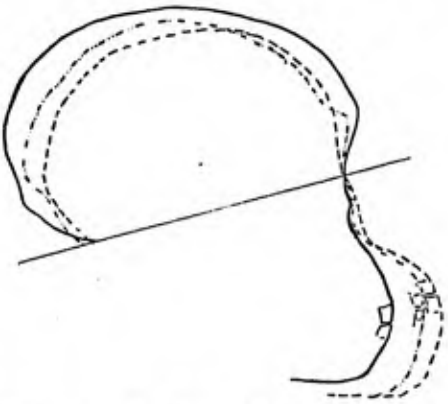

FIGURE 16. Profiles of the skull of the Taungs Ape superimposed on those of a Chimpanzee and an Orang of corresponding age (i. e. at the time of eruption of the first permanent molar tooth) by Dr. John Beattie.

The unbroken line represents the Taungs Ape, whose brain-case is larger and face smaller and less projecting than those of the other Apes. The Orang has a smaller brain-case and a more prominent jaw than the Chimpanzee.

foramen magnum—which Professor Dart assumed to afford further corroboration of its human affinity—is merely an infantile trait that is found equally in other young Anthropoids.[1]

Professor Dart was at first inclined to assume that the

[1] For an interesting discussion of the significance of this discovery see Robert Broom, 'On the Newly Discovered South African Man-Ape', *Natural History*, 1925, p. 409, and in a later number of the same Journal, 1926, p. 315, a fuller account entitled 'Taungs and its Significance', by Professor Dart himself.

posture of the young Taungs Ape was different from that of the Chimpanzee. The poise of the head of the simian infant resembles Man's much more nearly than that of the adult Ape does. Professor Bolk, of Amsterdam, has called attention[1] to the fact that the new-born Gorilla and Chimpanzee present a number of features —not merely in the brain-case and face, but also in skin-colour, distribution of hair, proportions of limbs, and condition of the reproductive organs—that become profoundly modified or lost in the course of the Ape's growth to the adult condition, but are retained in Man and have been assumed to be distinctively human traits. This observation is yet another token of the near affinity of the Apes to Man. But Professor Bolk has used it with great ingenuity in support of a remarkable hypothesis. According to him Man is, so to speak, an Ape that hasn't grown up—a sort of simian 'Peter Pan'. He attempts to explain the emergence of the distinctive human characters as the result of some restraining influence upon the Ape's development. The ductless glands—now commonly distinguished as endocrine—have been shown to exert a profound influence upon growth and metabolism; and Professor Bolk, like many other speculative writers in recent years, claims that something has upset the balance of the complicated chemical control of growth and development so as to inhibit the full emergence of the features distinctive of the full-grown Ape. In the transition of the Ape to Man and also in the transition of the Black Man to a paler condition some restraining influence is at work to prevent the hair, skin-colour, and many other features developing as they do in the Apes. But Man is not simply a simian infant! The great distinctive feature of the Human Family is an enormous active growth and development of the brain and a profound transformation of its mental powers, which are left unexplained by Bolk's speculation. Perhaps the

[1] 'The Part played by the Endocrine Glands in the Evolution of Man', *The Lancet*, 10 September 1921, p. 588.

great increase in the mass of nervous tissue itself provides the chemical factor that disturbs the balance of the endocrine organs, and through their altered activity inhibits the human infant's development of hair and skin pigment. But interesting as such speculations are, they lack any sort of corroboration. Morever, they shed no light upon the essential factor that makes Man the most intelligent of all living creatures.

Right-handedness.

To one who considers what precisely it means to fix the attention and attempt the performance of some delicately adjusted and precise action, it must be evident that one hand only can be usefully employed in executing the consciously skilled part in any given movement. The other hand, like the rest of the muscles of the whole body, can be only auxiliary to it, assisting, under the influence of attention, either passively or actively, in steadying the body or helping the dominant hand. Moreover, it is clear that if one hand is constantly employed for doing the more skilled work, it will learn to perform it more precisely and more successfully than either would if both were trained, in spite of what ambidextral enthusiasts may say. Hence it happened that when Nature was fashioning Man the forces of natural selection made one hand more apt to perform skilled movements than the other. Why precisely it was the right hand that was chosen in the majority of mankind we do not know, though scores of anatomists and others are ready with explanations. But probably some slight mechanical advantage in the circumstances of the limb, or perhaps even some factor affecting the left side of the brain that controls its movements, may have inclined the balance in favour of the right arm; and the forces of heredity have continued to perpetuate a tendency long ago imprinted in Man's structure when first he became human.

The fact that a certain proportion of mankind is left-handed, and that such a tendency is transmitted

to some only of the descendants of a left-handed person, might perhaps suggest that one half of mankind was originally left-handed and the other right-handed, and that the former condition was recessive in the Mendelian sense, or that some infinitesimal advantage may have accrued to the right-handed part of the original community, which in time of stress spared them in preference to left-handed individuals. But the whole problem of why right-handedness should be much more common than left-handedness is still quite obscure. The superiority of one hand is as old as mankind, and is one of the factors incidental to the evolution of Man.

It is easily comprehensible why one hand should become more expert than the other, as I have attempted to show; and the fact remains that it is the right hand, controlled by the left cerebral hemisphere, which is specially favoured in this respect. This heightened educability of the (left) cerebral hemisphere (for the right hand) has an important influence upon all its activities. When the Ape-Man attained a sufficient degree of intelligence to wish to communicate with his fellows other than merely by instinctive emotional cries and grimaces, such as all social groups of animals employ, the more cunning right hand would naturally play an important part in such gestures and signs; and, although the muscles on both sides of the face would be called into action in such movements of the features as were intended to convey information to another (and not merely to express the personal feelings of the individual), such bilateral movements would certainly be controlled by the left side of the brain, because it was already more highly educated. In the third chapter, after the problems of the human brain have been further discussed, I shall return to this problem of right- and left-handedness.

The Origin of Speech.

This argument will be further elaborated later on in this book to explain the origin of speech. The

increasing ability to perform actions demanding skill and delicacy received a great impetus when the hands were liberated for the exclusive cultivation of such skill; this perfection of cerebral control over muscular actions made it possible for the Ape-Man to learn to imitate the sounds around him, for the art of learning is a training not only of the motor centres and the muscles concerned, but also of all muscles, because posture involves the whole body and it is more or less concerned in every act. The benefits that accrued from educating the hands added to the power of controlling other muscles, such as those concerned with articulate speech.

The usefulness of such power of imitating sounds could be fully realized in Primitive Man, not only because he had developed the parts of the brain that made the acquisition of such skill possible, but also because he had acquired, in virtue of the development of other cortical areas, the ability to realize the significance and learn the meaning of the sounds heard.

I do not propose to discuss the tremendous impetus the invention of speech must have given in the accumulation of information to stimulate intellectual development. It enabled the knowledge acquired by each individual to become the property of the community and be handed on to future generations. It provided in words the very symbols and the indispensable instruments of the higher mental processes.

We are apt to forget the immensity of the heritage that has come down to us from former generations of men, until we begin dimly to realize that for the vast majority of mankind almost the sum total of their mental activities consists of imitation or acquiring and using the common stock of beliefs. For this accumulation of knowledge and its transmission to our generation we are almost wholly indebted to the use of speech. In our forgetfulness of these facts we marvel at the apparent dullness of Early Man in being content to use the most roughly chipped flints for many thou-

sands of years before he learned to polish them, and eventually to employ materials better suited for the manufacture of implements and weapons. But when we consider how slowly and laboriously Man acquires new ideas, and how such ideas—even those which seem childishly simple and obvious to us—were treasured as priceless possessions and handed on from tribe to tribe, it becomes increasingly difficult to believe in the possibility of the independent evolution of similar customs and inventions of any degree of complexity.

In this chapter I have attempted to deal with old problems in the light of newly acquired evidence; to emphasize the undoubted fact that the evolution of the Primates and the emergence of the distinctively human type of intelligence are to be explained primarily by a steady growth and specialization of certain parts of the brain; that such development could have occurred only in the Mammalia because they are the only plastic class of animals with a true organ of intelligence; that an arboreal mode of life started Man's ancestors on the way to pre-eminence, for it gave them the agility; and the specialization of the higher parts of the brain incidental to such a life gave them the seeing eye, and in course of time also the understanding ear; and that all the rest followed in the train of this high development of vision working on a brain which controlled ever-increasingly agile limbs.

If, in pursuing these objects, I may have seemed to wander far from the beaten paths of anthropology, as the word is usually understood, and perhaps encroached upon the domains of zoology, my aim has been to demonstrate that the solution of these problems of human origins, which have frequently engaged the attention of anthropologists, is not to be sought merely in comparisons of Man and the Anthropoid Apes. Man has emerged not by the sudden intrusion of some new element into the Ape's physical structure or the fabric of his mind, but by the culmination of those processes which have been operating in the same way

in a long line of ancestors ever since the beginning of the Tertiary Period.

The Piltdown Skull.

The foregoing pages represent (with some recent additions) the substance of an address to the British Association delivered in the autumn of 1912. Within the month after its delivery a dramatic confirmation was provided of the argument that in the evolution of Man the brain led the way. For the late Mr. Charles Dawson (in association with Dr.—now Sir Arthur—Smith Woodward) brought to light in Sussex the remains of a hitherto unknown type of Primate with a brain that, so far as size is concerned, came within the range of human variation, being more than 200 c.cm. larger than that of the more ancient and primitive member of the Human Family (*Pithecanthropus*), in association with a jaw so like that of a Chimpanzee that many of the leading palaeontologists believed it to be actually the remains of that Ape. The fragments of this very ancient human skull were found in a river gravel near Piltdown in Sussex. The facts relating to their discovery and the nature of the material have been so lucidly expounded in the excellent little handbook[1] issued by the British Museum (Natural History)—where the fossils are housed—that I need not refer in detail to the matters which have been made so readily accessible. The book is written by Sir Arthur Smith Woodward, who had to create a new genus and species (*Eoanthropus Dawsoni*) for the reception of this hitherto unknown member of the Human Family.

The remains can be confidently referred to the beginning of the Pleistocene Period. Hence they are almost as ancient as (if they were not actually contemporaneous with) the oldest-known member of the Human Family, *Pithecanthropus*, who was living thousands of miles

[1] *A Guide to the Fossil Remains of Man in the Department of Geology and Palaeontology in the British Museum (Natural History)*, third edition, 1922.

away in Java, also at the beginning of the Pleistocene Period. But there is a profound contrast between these two earliest-known members of the Family. While both of them retain many Ape-like features *Eoanthropus* has advanced much farther in the direction of *Homo sapiens* than the low-browed and obtrusively simian *Pithecanthropus*. When the fossils were discovered in 1912 it was a fortunate circumstance that they came into the hands of Dr. (afterwards Sir Arthur) Smith Woodward. For he appreciated their significance and interpreted them in a way that after thirteen years of controversy is now generally admitted to be correct in most essential respects. The brain-case differs so profoundly from those of *Pithecanthropus* and Neanderthal Man as to have been mistaken by many anthropologists for *Homo sapiens*, because it lacks the prominent eyebrow-ridges that it had been customary to associate with primitive Man. Yet it was found in association with the fragment of a jaw presenting so close a resemblance to the type hitherto known only in Apes that for more than twelve years many competent biologists have been claiming it to be the remains of a Chimpanzee. Reading again in the light of our present knowledge the history of this amazing error—one however that is particularly illuminating at a time when Man's kinship with the Apes is being denied by many writers—it is clear that some of the anthropologists in foreign countries, not having examined the actual fossils, misunderstood Sir Arthur Smith Woodward's account of them. He emphasized the human characters of the brain-case so as definitely to establish the fact that the early Pleistocene fossils were beyond question the remains of a member of the Human Family. While he entertained no doubt that the jaw found with the skull was actually a part of the same individual he called particular attention to its simian features to justify his action in creating a new genus for the reception of Piltdown Man. Those of us who were privileged to be associated with Sir Arthur

Smith Woodward in these investigations (in 1912 and 1913) failed to detect any source of confusion in these claims. But it is now apparent that many of those who were drawing inferences solely from the published reports (and the plaster casts of the specimens) failed to realize that the brain-case, although unquestionably human, presents a number of very primitive features that were not sufficiently emphasized in the early reports; and that the jaw and teeth, in spite of their superficial likeness to the Chimpanzee's, were definitely human. There was therefore no warrant for assuming that Nature had played the amazing trick of depositing in the same bed of gravel the brain-case (*without* the jaw) of a hitherto unknown type of Early Pleistocene Man displaying certain unique simian traits, alongside the jaw (*without* the brain-case) of an equally unknown Pleistocene Ape displaying human traits unknown in any Ape. But if it seemed difficult to believe that such a chance association—an Ape-like Man who left his brain-case without a jaw alongside the jaw of a supposed Man-like Ape who had left no brain-case—really happened once, the faith of even some of those who had most obstinately refused to admit that the jaw was human was not adequate to sustain a second miracle of the same sort. For when some years later Mr. Dawson found fragments of a second skull precisely similar to the first, but in a patch of gravel two miles distant from the site of the earlier discovery, and with these a molar tooth like those set in the supposed Ape's jaw, it became clear that the association was not fortuitous. The primitive human brain-case with simian traits was really part of the same individual as the more obtrusively Ape-like jaw. But when the original skull was reconstructed in strict accordance with the anatomical evidence imprinted in the texture of each fragment a brain-case unlike that of any other human type was revealed, which harmonizes with the much-disputed jaw. The skull is at least as Ape-like in its architecture as the more obvious shape of the jaw is.

The Reconstruction of the Skull.

In spite of the controversies of 1913 and the succeeding years there has never been any justification for the doubts that have been expressed as to the methods to be adopted for (and the results that emerged from their application in) the reconstruction of the skull. The relevant facts I explained in 1913 and 1914.[1] No cause of dispute need have arisen if the only justifiable procedure had been adopted—to study the evidence revealed in the fragments themselves and build up the skull in strict accordance with the facts. It is unwarrantable in a case of a skull of unknown type to take a specimen of *Homo sapiens* and make a spurious caricature of it—spurious because the presence of the sutures (lambdoid and sagittal) was ignored in the process of creating the caricature.

The one and only way to make an accurate restoration of the Piltdown skull is by observing and giving expression to the following facts. The large fragment (Fig. 17) includes part of the frontal bone, almost the whole of the left parietal bone, and small fragments of the right parietal bone (Fig. 18). The true median line of the brain-case is indicated by a ridge (Fig. 20) upon the inner (endocranial) surface of the frontal bone, and upon the upper surface (Fig. 18) the extreme anterior and the extreme posterior (closed) parts of the sagittal suture. Hence the major part of the left side of the brain-case can be orientated with certainty. Sufficient of the right parietal bone (Fig. 18) is preserved to put it into a position (Figs. 18 and 21) approximately symmetrical to that of the left parietal. The word 'approximately' is not used here with the implication that the true position of the bone is not known. All that is intended is that the two parietal bones reveal the asymmetry that is customary in

[1] *Nature*, October 30, p. 267, and November 13, p. 318, 1913; *Quarterly Journal of the Geological Society*, March 1913, vol. lxix, p. 117; April 1914, vol. lxx, p. 93; and March 1917, vol. lxxiii, p. 1; *Bedrock*, 1914, vol. 3, p. 1.

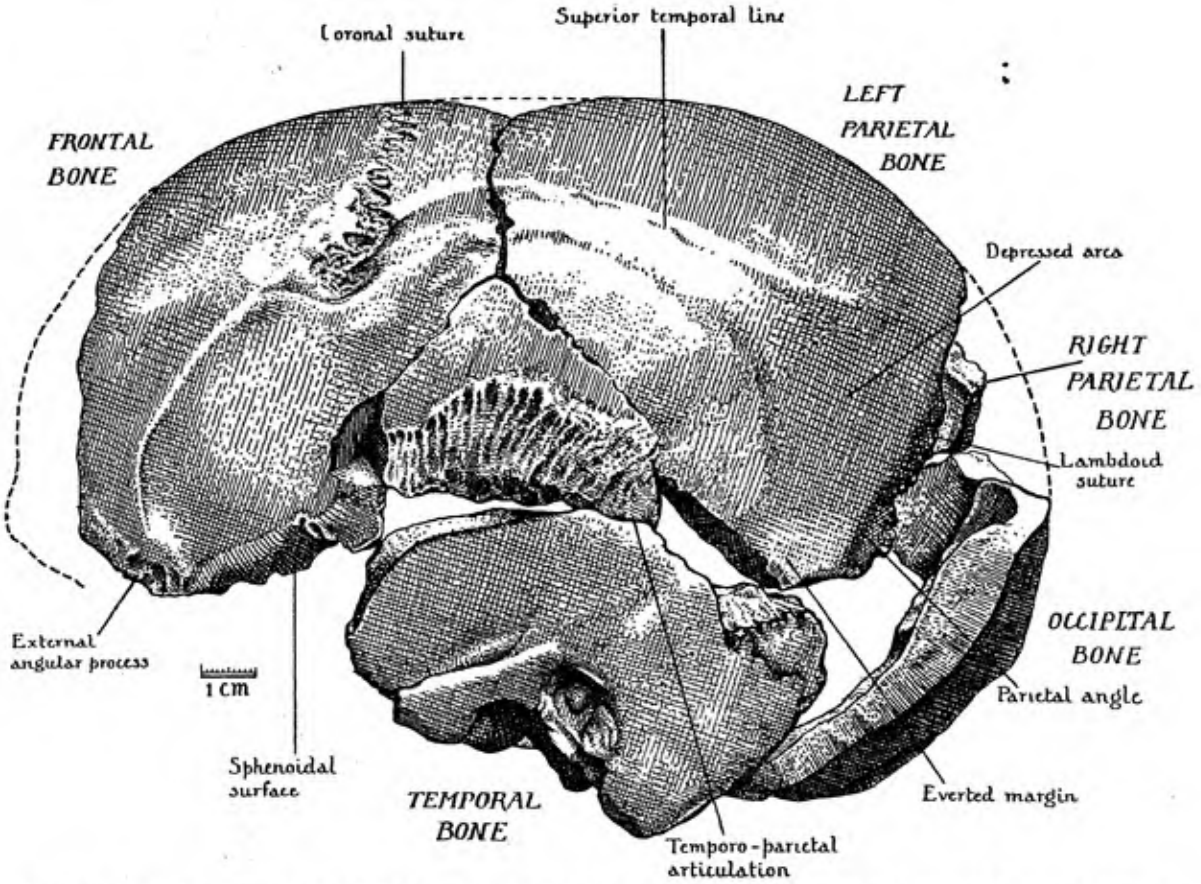

FIGURE 17. Fragments of the Piltdown skull put into their relative positions and viewed from the left side. $\times \frac{11}{15}$. Drawn by T. L. Poulton.

human skulls: so that a position of absolute symmetry is impossible. For the distance of a few millimetres the lower margin of the left parietal bone articulates with the upper margin of the temporal bone (Fig. 17) in such a way that their relative positions are absolutely fixed. There only remains the problem of determining the true position and orientation of the occipital bone. In doing this it must be remembered that on the left side the upper and lower parts of the lambdoid suture are actually present on the large (fronto-parietal) fragment —an important fact that has been repeatedly ignored in most of the published accounts of so-called reconstructions of this skull, the upper part of the suture in the median plane (Fig. 19, *L*) being usually overlooked. On the right side several digitations of the lambdoid suture are present on the parietal bone (Fig. 19, *L*). As the right and left parietals have already been put into their appropriate positions these indications of the two halves of the lambdoid suture afford an additional test of the accuracy of these positions. Some digitations of the lambdoid suture are also on the right fragment of the occipital bone, which can therefore be brought into line with the rest of the lambdoid suture that has already been determined. As the main piece of the occipital bone can be brought into relationship with the smaller piece, the former provides indications in the external occipital crest of the middle line of the whole bone, which of course should coincide with the backward prolongation of the median plane determined from the frontal and parietal bones (Fig. 19). Having settled the position of the occipital with reference to the lambdoid suture and the median plane, the inclination of the bone—in other words the exact position of its lower border—alone remains to be determined. Fortunately for us it is possible to do this with accuracy, because when the bone was broken a small part of the condyloid fossa remained. Examination of a series of crania of Men and Apes reveals that the posterior part of this fossa bears a constant relationship to the groove

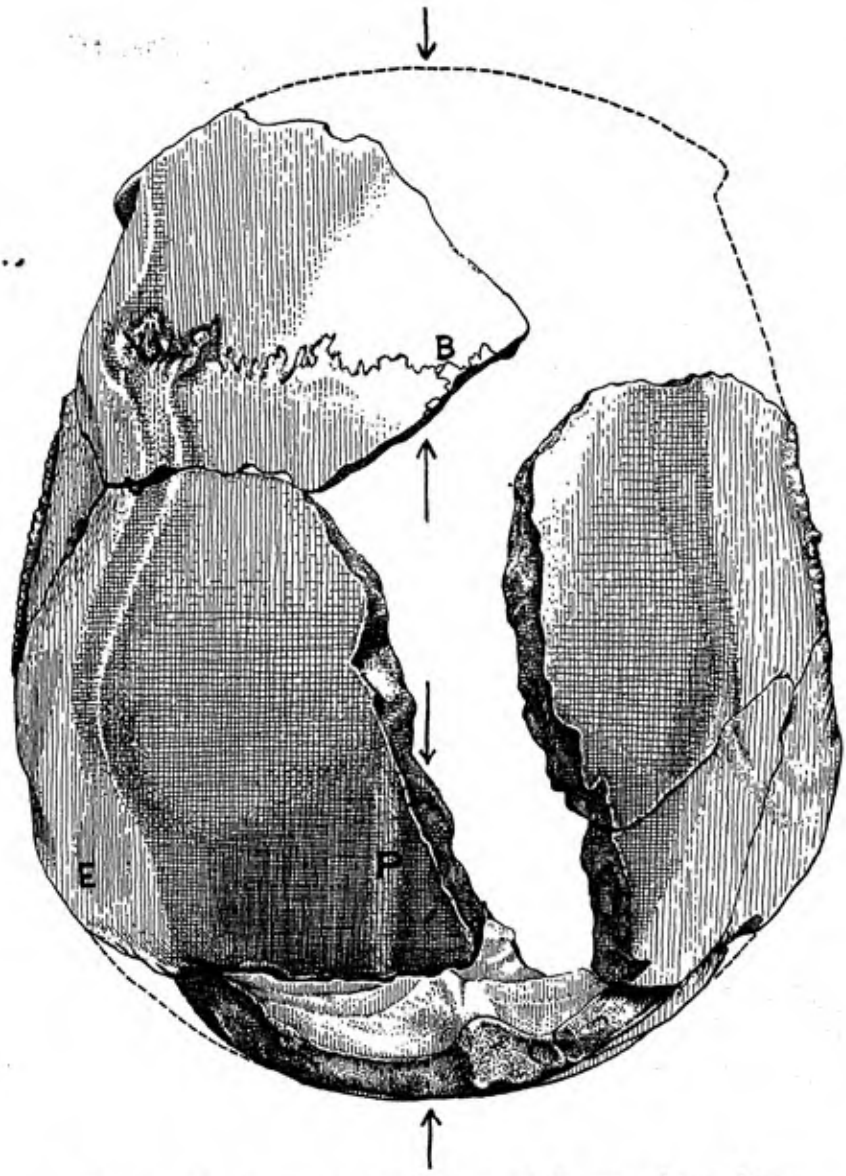

FIGURE 18. Fragments of Piltdown skull seen from above. × $\frac{11}{12}$. Drawn by T. L. Poulton. The arrows indicate the true median plane.

B, union of coronal and sagittal sutures.

P, parasagittal crest (to medial side of which is seen the obliterated part of the sagittal suture).

E, depressed area above a very distinctive eversion of the postero-inferior angle of the parietal.

for the lateral sinus on the temporal bone—the former lies immediately behind the transverse line corresponding to the posterior lip of the temporal groove for the lateral sinus.

Although these principles were set forth in my

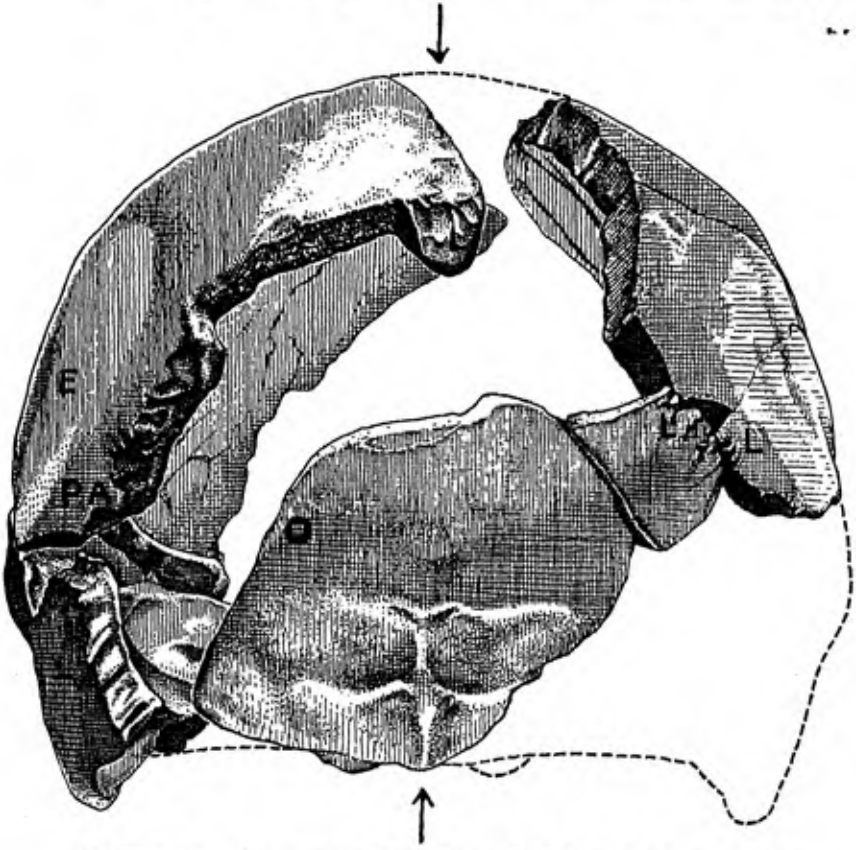

FIGURE 19. Fragments of Piltdown skull from behind. × 11/15. Drawn by T. L. Poulton.

E, depressed area above the everted margin of parietal (compare Fig. 17).

PA, area to medial side of the parietal angle (see Fig. 17) that is on the same plane as the occipital (*O*) and confirms the accuracy of the latter's orientation.

L, *L*, *L*, various fragments of lambdoid suture; another part to the medial side of the letters *PA* is not labelled.

writings in 1913 and 1914, it was not until 1921 that I was able to get them expressed in a model of the restored skull, which the late Professor John Irvine Hunter made for me, and exhibited at the Anatomical Society in 1922. At his request I withheld the publica-

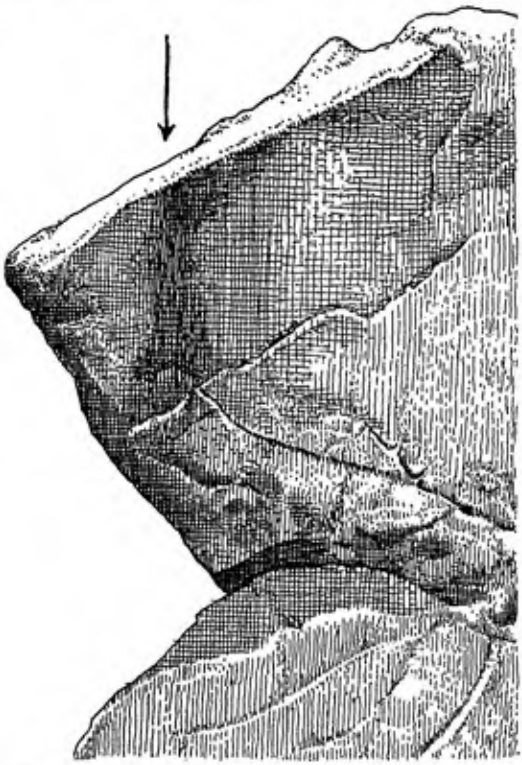

FIGURE 20. The inner surface of part of the largest fragment of the Piltdown skull to show the median crest (in line with the arrow). Nat. size.

tion of our restoration until he could return to England to test every detail again. He was about to set to work on this task in December 1924, when his death occurred. Dr. John Beattie then helped me to revise the restoration represented in the accompanying drawings.

The correction of the orientation of the occipital

bone reduces the cranial capacity to exactly the figure —1,170 c.cm.—originally given by Sir Arthur Smith Woodward in 1912, but uncertainty as to the exact form of the under surface of the front end of the brain raises the possibility that the capacity may have been as much as 1,200 c.cm. It is thus definitely well below

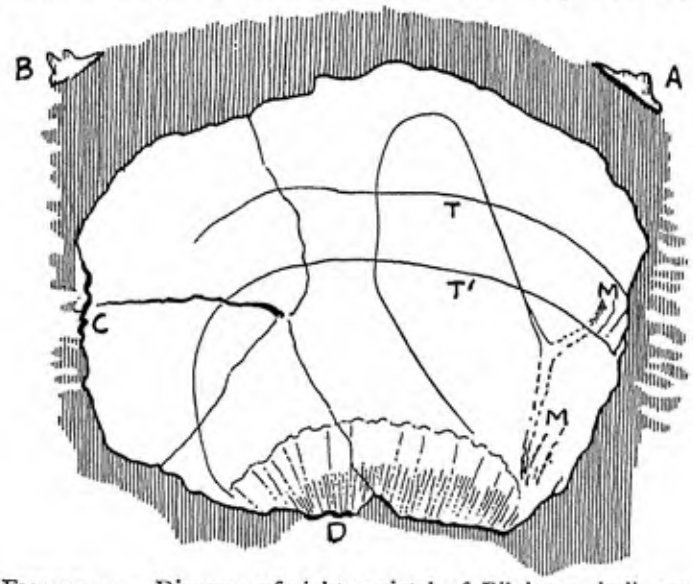

FIGURE 21. Diagram of right parietal of Piltdown skull superimposed upon a rough sketch of the left parietal.

Coincidence of the sutures at *C* and *D*, of the meningeal grooves at *MM*, and the temporal lines at *T* and *T'* afford the means of determining their relative positions.

At *A* and *B* other fragments of the *right* parietal bone are shown (quite diagrammatically).

the average size of the human brain, though well within the range of its variation. But its chief interest lies not simply in its small size, but in the relatively poor development of the three areas of chief significance. These features will be considered in a later chapter.

In most of the attempts to reconstruct the Piltdown skull the right parietal bone has been displaced backward. Its correct position is indicated in the diagram (Fig. 21), in which it is shown in relation to the left

parietal. Many details of its structure indicate this to be its only possible position with reference to its fellow.

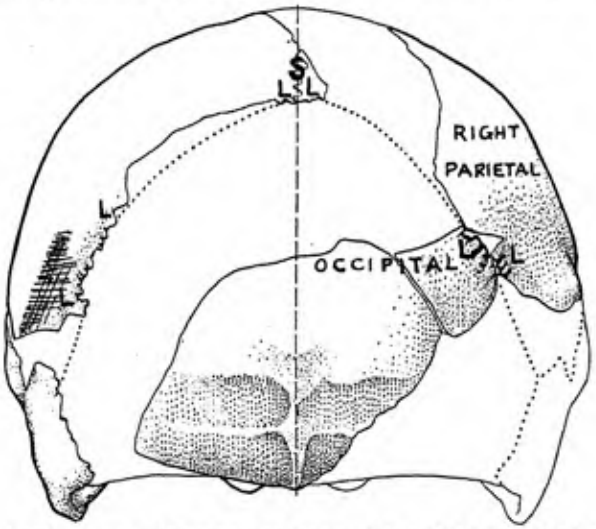

FIGURE 22. Diagram of back of the Piltdown skull to show the various parts of the lambdoid suture (*LLLLLL*) on three of the fragments. *S* marks the place where the posterior end of the sagittal suture is closed. × ½.

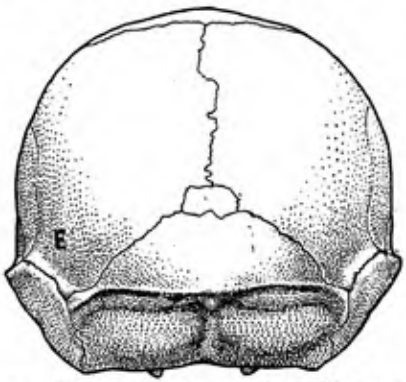

FIGURE 23. The back of a young Chimpanzee's skull to show the general similarity of form and in particular the eversion (*E*) of the postero-inferior angle of the parietal bone. × ½.

But the restoration of this bone to its true position, in addition to establishing the symmetry of the lambdoid

suture (Fig. 22, *L*) necessarily raises the occipital bone into a position that is nearer the vertical—because on the right side (Fig. 22) part of the lambdoid suture (*L*) is on the occipital and part on the right parietal bone, so that if the latter is pushed forward the occipital must be raised up, i.e. its upper part rotated forward. The peculiar conformation of the left parietal bone further establishes the correctness of this orientation of the occipital. For near its postero-inferior angle, at what I have called the 'parietal angle' (Fig. 17), the bone is bent in a way that is quite distinctive. The surface behind this bend (Fig. 19, *PA*) is brought into a plane corresponding to that of the occipital bone, so that all doubt as to the correctness of the latter's orientation vanishes.

When the skull is restored in this way its conformation is quite distinctive, and differs profoundly from all other human skulls, recent or fossil. The parietal bone exhibits a peculiar depression (Fig. 17, Depressed area) between the diverging temporal lines, and the lower margin of the bone, below the depression, is everted (Fig. 17, Everted margin). This creates a peculiarity in the form of the cranium that is found in the Gorilla and Chimpanzee (Fig. 23, *E*). But the simian resemblances are revealed most strikingly in a transverse section of the reconstructed Piltdown skull, when compared with corresponding sections of those of a Chimpanzee, a Gorilla, and a modern European (Fig. 24). It will then be realized how much more nearly the Piltdown skull approaches the simian type. The general form of the cranium in transverse section is greatly expanded like that of an Ape. This applies particularly to the contour of the parietal bones. But the construction of the temporal bone is even more strikingly Ape-like in character. The squama and the petrous temporal are not only very massive, but they unite at an obtuse angle that contrasts with the approximately right-angled relationship usually found in Man. In this respect the Piltdown temporal bone is definitely

intermediate in type between those of the Apes and Men of the genus *Homo*.

These simian peculiarities of the Piltdown skull are intimately correlated with the distinctive features of the brain as revealed in the endocranial cast.

It must not be assumed that the peculiar features of the skull are due to the method of reconstruction I

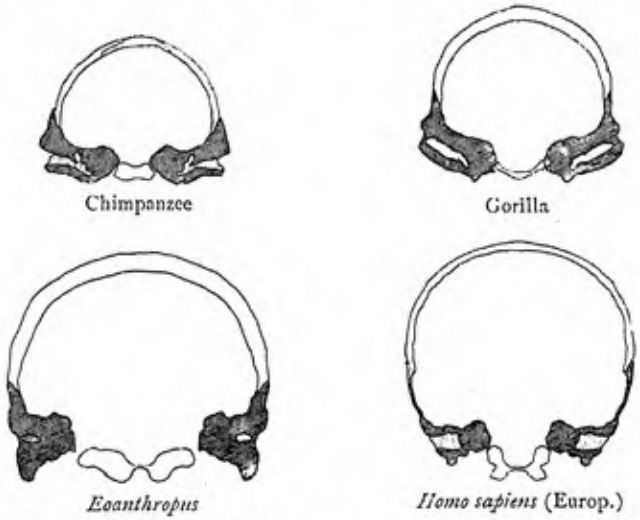

FIGURE 24. Drawings of transverse sections through the crania of a Chimpanzee, a Gorilla, the reconstructed Piltdown skull, and a Modern Man's skull, by the late Professor John Irvine Hunter. The sections pass through the external auditory meatus.

have been explaining. The temporal bone reveals its distinctive features apart from its articulation with the other bones. In the case of the left parietal bone all four corners are present. Hence (altogether apart from the rest of the cranium) one can state as a positive fact that it is exceptionally small. Moreover, it is flatter than perhaps any known human parietal bone, excepting only that of *Pithecanthropus*, which is modelled, however, into a sharply contrasted form. Thus, without making an actual restoration of the

brain-case of the Piltdown skull, the exceptional smallness and flatness of the parietal bones prove conclusively the utter impossibility of the cranial capacity being other than small.

There are many other simian features in this skull; but enough has been said to establish the two issues that concern us in the argument of this book. First, the Piltdown brain-case reveals features of simian likeness that harmonize with the jaw with which it was found. Secondly, the facts that I have set forth should be sufficient to convince the reader that when in the subsequent chapters we have to consider the size and form of the brain we shall not be dealing with a hypothetical restoration but with one that is surely founded upon the internal evidence of the fossil fragments themselves.

Particular attention should be called to the asymmetry of the endocranial aspect of the posterior end of the brain-case of *Eoanthropus* (Fig. 18). It does not affect the external form of the skull (Fig. 19), which is much less asymmetrical. Further reference to the meaning of this will be made later in this book (p. 184).

Since this chapter has been printed Dr. Adolph H. Schultz has published a very comprehensive report on the differentiation of Apes and Men ('Fetal Growth in Man and Other Primates', *The Quarterly Review of Biology*, vol. i, 1926, pp. 465–521), which provides a great mass of evidence in confirmation of the general conclusions in this chapter.

CHAPTER II

PRIMITIVE MAN

We may now turn to the history of Man himself, and in doing so I may remind you of the opinion expressed by an American historian that 'the widening outlook of both anthropologists and historians, as well as the requirements of science, demands the co-ordination of these two phases of humanistic inquiry'.[1]

Professor Teggart becomes more explicit when he claims that 'by insensible degrees the historian has come to see that there is no hard and fast boundary between "historic" and "prehistoric" times, between "historical" and "unhistorical" peoples; the history of Man includes man everywhere and at all times'.

Approaching the same question from the anthropological side, biologists who have examined the remains of Early Man, and studied the elements of culture found in association with them, have arrived at the same conclusion. For, as Professor Henry Fairfield Osborn has recently expressed it, such investigations reveal 'the great antiquity of the spirit of man and the fundamental similarity between the great steps of prehistory and history'.[2]

But the terms 'prehistoric', 'prehistory', must be renounced, or used only in the most general sense, by all who value clearness of thought and precision of statement. When the adjective first came into use there was a vast break of unknown extent between the history of Man as preserved in written documents and the complementary story as recorded in what was then the less legible palimpsest of bones, implements, and potsherds. With the accumulation of further

[1] Frederick J. Teggart, *Prolegomena to History*, University of California Publications in History, vol. iv, No. 3, 1916, p. 124.

[2] *Men of the Old Stone Age*, 1915, p. 501.

information and the acquisition of a fuller insight into the meaning of the latter kind of evidence, the gap between the historical and the so-called 'prehistoric' has been to a large extent bridged, and by evidence of contact between neighbouring peoples the two 'ages' been shown to overlap. Moreover, the unwritten records preserved in the bones and cultural remains have become more and more comprehensible, and have given us perhaps a fuller and more truthful history of certain phases of man's activities than the written documents, which are often coloured and distorted by the personal bias of their authors, though it has been the custom to regard them as the only sources of real history.

One has only to recall the recently acquired knowledge of the archaeology of Crete and Nubia, for example, to realize the vastness and the accuracy of the body of history that has been recovered from sources other than literary records. Not only have such researches revealed a very extensive chapter of positive history, but they have shed a new light upon the hitherto accepted interpretation of the written documents and forced a considerable reorientation of the ideas they had provided of the growth of civilization.

With the widening of outlook and the growth of the conception of continuity in history, the term 'prehistoric' has, in fact, lost much of its usefulness. It has now become a hindrance rather than a help to those who are striving to obtain a clear view and a right perspective of Man's history as a closely interrelated whole and of the essential unity of civilization. Hence, except perhaps in the case of some small localized area, it would be a distinct advantage if the word 'prehistoric', and all the misleading and confusing glamour that has grown up in association with it,[1]

[1] The influence of this confusion is repeatedly shown in the writings of modern scholars, who are perfectly familiar with the fact that the so-called 'prehistoric' culture of Western Europe endured for several millennia after the inauguration of the 'historical' period in

were relegated to the oblivion of the past to which it naturally belongs.

Once these obstructions are cleared away we can get back to the view expressed by Diodorus and the Stoics, that 'all men living, or who once lived, belong to the common Human Family, though divided from one another by time and space' (Bury's translation), and regard history as including 'not alone every manifestation of political activity among men, but the entire range of human experience' (Teggart).

The term 'Primitive', which I have ventured to use in the title of this chapter, is also open to grave objection, unless it is definitely restricted to those classes of beings and events to which it can be applied without obvious ambiguity. While it is legitimate to employ it with reference to really early types of mankind and to survivals of practices and beliefs which have come down from the very childhood of the human race—and that is the sense which I had in mind when I selected 'Primitive Man' as the title of this chapter—it is necessary to protest against the common misuse of this expression, of which modern ethnologists in particular are guilty. For instance, it has become a practice to refer to all the customs and traditions of such peoples as the aboriginal Australians and the Bushmen of South Africa as 'primitive', although it is patent that many of these elements of culture, and especially those which are most often used as illustrations of 'primitive' beliefs and practices, and labelled as such, have been borrowed in relatively recent times from more advanced and alien civilizations.

It is very questionable whether any pure strains

the Eastern Mediterranean. Yet the bias created by the employment of the word 'prehistoric' with reference to the former often leads writers unwittingly to invert the course of history, and refer to crude elements of 'prehistoric' Western European culture that were unquestionably derived from the earlier and more perfect institutions of the 'historical' East as the parents instead of the offspring of the latter.

of mankind exist at the present time. During its wanderings in past ages every people has certainly come into more or less intimate contact with alien races and mingled with them. But even though, so far as mere physical structure is concerned, several races may seem relatively uniform in type and appear to be really primitive and unmixed, their customs and beliefs reveal the more obtrusive influence of contact with and borrowing from other peoples.

But in this chapter I am concerned mainly with those earlier types of mankind that are really primitive, and I shall refer to modern man and his works only to emphasize the fact that the human spirit has ever remained the same. Even when it becomes encrusted with the influences, good and bad, of traditions which have been accumulating and affecting Man's outlook ever since he first emerged from the simian stage of complete individualism, human nature is based upon the same primitive instincts and emotions.

The objection may be raised that the investigation of a few fragments of fossilized bone cannot shed any light upon human behaviour and history. But it must be remembered that these human remains have been found in association with evidence of Man's handiwork. It has been necessary to study the two kinds of evidence in correlation the one with the other before it became possible to form an adequate conception either of the nature of the men themselves and the times in which they lived or of the real significance of their industries. Hence the investigation of these primitive men's motives and capabilities came to form a necessary and integral part of the task of interpreting the meaning of the bodily remains. In reading such documents, even though they are seen darkly through the glass of untold ages, the inquirer is really reading historical records. Moreover, they are records of real facts, uncoloured by the emotions and the prejudices of a partisan interpreter. For the actions and the motives of these primitive men are known by their

works, and not merely second-hand from the often ill-founded opinions of some partial scribe, who may have had some conscious reason for distorting the facts, or in any case was not fully competent to escape the influence of those unconscious phenomena that warp the judgement of all men, however conscientious.

But even though only the smallest scraps of evidence have been preserved to illuminate the working of the mind of Primitive Man, they shed a very clear light upon the ways of mankind as a whole. For they reveal his manner of thought and action, stripped of much of the confusion that the accumulations of traditions and stereotyped ideas have created to obscure one's vision of modern men's motives.

In spite of their obvious differences in physical structure and intellectual achievement, all the living races of mankind are regarded merely as varieties of one species, *Homo sapiens*. It was not until the year 1848 that there first came to light the remains of a type of mankind so vastly older than and so different in structure from all the then known varieties of men, living or extinct, as to be regarded by many recent writers as the representative of another species, for which Dr. Falconer, in 1868, suggested the name *Homo calficus*, in reference to Gibraltar, the ancient Calphe. But the real significance of the Gibraltar skull was not appreciated at the time of its discovery. In fact it is only during the present century that scientists have begun to realize how momentous was the new era in our knowledge of Man which was inaugurated when Lieutenant Flint found this fossilized skull near the Forbes Quarry at Gibraltar in 1848. In that year Europe was in a state of profound unrest. Revolution had occurred in France, and the other European states were not free from the risks of coming trouble. In these circumstances all the Powers were putting their defences in order. It is a strange reflection that these military preparations inspired by political unrest should

have been responsible for the recovery of the first representative of an extinct species of the Human Family that we know of.

But before this specimen had come to the knowledge of any one capable of appreciating the fact that it was an important discovery, the remains of another individual, possibly of the same race, but certainly of the same species, came to light in a Neanderthal cave near Düsseldorf in 1856. These fragments included the upper part of a human skull, the more obtrusive features of which (for it was a man's, while the Gibraltar specimen was a woman's skull), no less than the fact that it came at once into the hands of a competent anatomist (Professor Schaafhausen), at once riveted attention upon it as the relic of a hitherto unknown type of the Human Family, which afterwards received the name *Homo neanderthalensis.* As this designation was suggested by Professor King of Galway in 1864, some years before Dr. Falconer proposed the specific name *calficus* for the Gibraltar skull, the former takes precedence of and excludes the latter, if it be admitted that the Neanderthal and Gibraltar remains belong to the same group, and that the latter is really of specific rank. It is a difficult question to decide whether or not there is sufficient justification for the creation of this new species of the genus *Homo*; but on the whole I think the balance of evidence is in favour of such a course.

But whether or not the Neanderthal race represents a distinct species which was succeeded in Europe by *Homo sapiens*, there can be no doubt that the advent of the latter more modern type of men in Europe represents on the cultural side the most momentous event in its history.

One of my chief aims in this chapter will be to consider the significance of this great step forward in the history of mankind, when there are revealed for the first time men of essentially the same type as ourselves, endowed with the same intellectual qualities and artistic aptitude.

FIGURES 25 and 26. Drawings of the front and right side of the Gibraltar skull, by T. L. Poulton.

When the Neanderthal skeleton came into the hands of Professor Schaafhausen he claimed that 'the extraordinary form of the skull was due to a natural conformation hitherto not known to exist, even in the most barbarous races', and that the 'human relics were traceable to a period at which the latest animals of the diluvium still existed'. Subsequent research and the discovery of much more material bearing upon the points at issue have proved beyond all possibility of error the soundness of these conclusions. But for years after these

FIGURE 27. Drawing of the right side of the Neanderthal skull, by T. L. Poulton.

statements were made a lively controversy raged around this skull, and in course of time, with the addition of the inflammable material supplied by Charles Darwin's classical works, a great conflagration developed. As Huxley remarked, many years afterwards: 'It was suggested that the Neanderthal skeleton was that of a stray idiot: that the characters of the skull were the result of early synostosis or of late gout: and, in fact, any stick was good enough to beat the dog withal.'

Since then many more remains of a variety of early types of mankind have come to light, as well as a great deal of information relating to the handiwork and

achievements of these primitive men, the animals they hunted, and the conditions under which they lived. But as this mass of facts has gradually increased there has also grown up in connexion with them a body of theory that has become so systematized as to make it extremely difficult to view the results impartially. Part of my aim is to strip away much of this speculative obstruction. In the days when only a very few fragments of bone and chipped flint provided all the information available for the study of Primitive Man, a scaffolding of hypothesis was necessary in order to make any sort of edifice of such broken and scanty debris. But now that so much more material is available it is possible to build up a structure capable of standing by itself. Hence this scaffolding is not only no longer necessary, but it interferes with the view of the building.

Almost every new discovery has started afresh such disputes as followed the finding of the Neanderthal skull, and history has repeated itself with remarkable consistency. The recent disputes concerning the significance of the fossil skull found by the late Mr. Charles Dawson near Piltdown in 1912 are true to type.

It has been said of the fossil jaw found in the Mauer sands near Heidelberg in 1908 that it was remarkable in many respects, and not least because it was the only fossilized fragment of a human being the discovery of which had not excited a violent controversy. But fortunately many further instances can be recorded since 1908 of the calm and dispassionate discussion of the problems arising out of fresh discoveries.

Long before the discovery of these actual fragments of the Man of the Old Stone Age, archaeologists had become aware of his former existence by finding implements of human workmanship in caves and in ancient gravels, often in association with the bones of extinct mammals. But it was not until the year 1887 that the Belgian scientists Fraipont and Lohest made the

discovery at Spy, one of the most important and fundamental in the whole history of the growth of our knowledge of Early Man, that the Neanderthal people were the makers of the type of stone implements which are now called Mousterian, and that they were contemporaneous with the Woolly Mammoth, the Woolly Rhinoceros, the Cave Bear, and the Cave Hyena in Western Europe.

This clearer vision of Mousterian Man (*Homo neanderthalensis*) in his natural surroundings stimulated further inquiries; and as the result of a long series of remarkable discoveries, no less than of the intensive investigation of the known material, especially by Schwalbe and Boule among many others, one has gained a surprisingly full view of the physical characters and the achievements of this peculiarly distinctive type of mankind, which occupied Europe many thousands of years ago.

The information that has been accumulating has illuminated not merely the Mousterian phase of industry and Neanderthal Man, but has revealed also a long succession of later cultural phases and waves of varied types of mankind, all of which, however, differ from the men of the so-called 'Lower Palaeolithic Age' in conforming much more nearly to the modern type.

In fact, however much uncertainty there may be as to whether or not the Neanderthal race really represents a distinct species, most authorities are agreed that all the races of the so-called 'Upper Palaeolithic' phase were merely varieties of the species *Homo sapiens*. In France there was a series of phases of culture associated with at least three successive waves of immigration into Western Europe during this period. These have been distinguished by the names of the places where the particular industries were first recognized: Aurignacian (from the small grotto of Aurignac, Haute-Garonne), Solutrean (from the station of Solutré, Saône-et-Loire), and Magdalenian (from the rock-shelter of La Madeleine, on the bank of the Vézère). Although the racial char-

acters of these successive waves of immigrants were probably quite distinct the one from the other, it is often convenient to refer to them collectively, for the purpose of contrast with the races of men who went before or came after them. In such cases some writers refer to these people of the so-called 'Upper Palaeolithic' Period as Crô-Magnon men, from the place-name

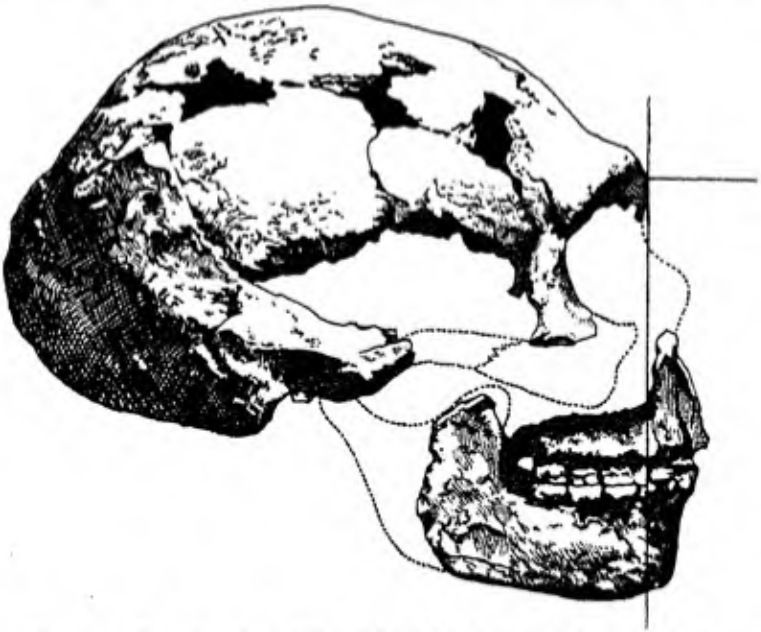

FIGURE 28. Drawing of the right side of one of the Spy skulls, by T. L. Poulton.

given to the first known representative of one of these races. In using this expression, however, the reservation must always be borne in mind that it covers a variety of racial types, of which the real Crô-Magnon Man is only one.

The last quarter of a century has also brought to light the fragments of four divergent and much more primitive members of the Human Family: the genus *Pithecanthropus*, found in Java in 1892 by Dr. Eugen

Dubois; the Heidelberg jaw, found in the Mauer sands by Dr. Schoetensack in 1908, which Bonarelli regards as the remains of a special genus, *Palaeanthropus*; the genus *Eoanthropus*, found by the late Mr. Charles Dawson near Piltdown in Sussex in 1912; and the species *Homo rhodesiensis*, created by Sir Arthur Smith Woodward in 1921 to include a hitherto unknown type found in the Broken Hill mine.

The small fragments of these four most primitive members of the Human Family afford us tantalizingly imperfect glimpses of Man in the making, and have, not unnaturally, supplied the material for some of the most lively controversies in the whole history of anthropology. There are still wide divergences of opinion in respect to almost every aspect of the problems raised for discussion by these relics.

Recent years have witnessed the extinction of the bitter animosities which, in the sixties and seventies of last century, were inevitably excited by the mere suggestion that Man was descended from the Apes. The fact of Man's descent is no longer questioned; but the intense theological emotions of fifty years ago have now given place to profound differences of opinion concerning the interpretation of the details of the technical evidence as to how Man and human institutions were evolved. Every human fragment and scrap of Man's handiwork that has been preserved to us from the Old Stone Age has become a nucleus around which the liveliest discussions have centred. The anatomist who investigates the features of the human remains, the archaeologist who explains the significance of the implements and culture, the zoologist and palaeontologist who deal with the associated fauna, and the geologist who interprets the circumstances under which the remains are found, all take their share in these discussions; and as the conclusion arrived at by each of these investigators has an intimate bearing upon the results obtained by workers in the other fields, there is ample scope for differences of opinion to arise. Perhaps the most

difficult problems of all are those that have been raised by the attempts to determine the changes of temperature and climate and the comings and goings of the various mammals, and to associate them with Man in the different stages of his chequered career in Europe.

This is not the place for the discussion of these technical controversies. What I propose to do is to set forth in general terms such conclusions as, I think, most scientists would be willing to admit, and then consider their wider bearing upon some of the fundamental problems of human history.

No human remains have yet come to light that can be referred with certainty to a time earlier than the Pleistocene. There are very definite reasons for including the Javan fossil *Pithecanthropus* within the Human Family, and also for regarding it as the most primitive member of that Family, though probably not on the direct line of ancestry of the higher races of men. In making this statement I should add that several leading palaeontologists, such as Professors Boule and Obermaier, still maintain that *Pithecanthropus* was really an Ape. Sir Arthur Smith Woodward, who has examined their arguments,[1] comes to the conclusion that 'there is thus some reason to suspect that Man himself lived in Java with *Pithecanthropus*, and that the latter was really a gigantic and precocious Gibbon'.

But in 1898[2] Professor Dubois clearly demonstrated that for a Gibbon to acquire a cranial capacity such as is found in the Java skull, it would indeed require, if it remained a true Gibbon, to be truly gigantic. For to attain a cranial capacity of 855 c.cm.—which is the size estimated by Dubois—it would need to be four times the stature of a man. So far from this

[1] 'Early Man', *Geological Magazine*, January, 1917.

[2] 'Remarks on the Brain-cast of *Pithecanthropus erectus*', *Proceedings of the Fourth International Congress of Zoology*, Cambridge, 1898, p. 91.

estimate of size being realized, the femur of *Pithecanthropus* indicates that the creature was not quite so big as an average man. But it is not only the mere capacity of the brain-case, but also the form of its interior that reveals the right of *Pithecanthropus* to be included within the Human Family. For the cranial cast reveals a special expansion of that area in the temporal region of the brain which recent research has led physicians to associate with the distinctively human faculty of speech. For these and other reasons I think that *Pithecanthropus* is really a member, if a very lowly one, of the Human Family.

Most authorities now assign its age to the Early Pleistocene; but some recent writers, without definitely denying this possibility, are inclined to agree with Dubois's original claim that it belongs to the Uppermost Pliocene. One of the reasons for this view is that the fossil elephants which occur in Java along with *Pithecanthropus* are also found twenty-five hundred miles away in the foot-hills of the Himalayas of India, where they are regarded as of the Uppermost Pliocene Age. But, as allied species did not arrive in Europe until Early Pleistocene times, there is the possibility that the animals whose remains have been found in Java may also not have wandered east before then. Thus it can be said, without the possibility of contradiction, that the earliest known representative of the Human Family can be referred approximately to the commencement of the Pleistocene Period, with the possibility that it may have been a little earlier. It is so ape-like that, as I have already remarked, some leading authorities still maintain that it is an Ape. Hence it is necessary to assume, until more precise evidence is forthcoming to invalidate the conclusion, that at the close of the Pliocene Period Man was still 'in the making'. The suggestion that the Nebraska tooth (*Hesperopithecus*) may possibly indicate the existence of Mankind in Early Pliocene times is, as I have explained in the Foreword, still wholly tentative. The claim that real

men were in existence in Pliocene and Miocene times must be regarded as a mere hypothesis unsupported as yet by any adequate evidence.

In making this statement I have not forgotten the extremely interesting fragments of jaw and teeth found (in 1911) in the Siwalik Hills by Dr. G. E. Pilgrim, who has created the new genus and species *Sivapithecus indicus* for its reception.[1] Although Dr. Pilgrim regards this Miocene creature as a member of the Human Family, I agree with the opinion expressed by Professor Boule[2] that the evidence afforded by these fragments is altogether inadequate to justify such far-reaching conclusions. The distinctive features of the Human Family can be provided only by the brain-case and the limb bones, which underwent the characteristic changes long before the jaws and face and rest of the body lost their simian characters. For in the process of the evolution of Man it was the brain which first acquired what can be called the human status. The earliest members of the Human Family must have been merely Apes with an overgrown brain, and probably the first bodily changes that occurred were the modifications of the legs for the new methods of progression, which were in the main the outcome of the higher development of brain. The simian features of the skin and hair, teeth and face, and the general configuration of the body, no doubt persisted for long ages after the changes in the brain and the legs had been established.

Thus, as I have already explained in the Foreword, it cannot be claimed that the characters of the teeth of any Miocene Ape reveal the existence of the Human Family at so remote a period of time. For the distinctive criteria of the earliest types of the Human

[1] 'New Siwalik Primates and their Bearing on the Question of the Evolution of Man and the Anthropoidea', *Records of the Geological Survey of India*, vol. xlv, part I, 1915.

[2] 'Les Singes fossiles de l'Inde d'après M. Pilgrim', *L'Anthropologie*, t. xxvi, 1915, p. 409.

Family can be provided only by the brain-case. The teeth and jaws can, however, give indications of human affinities. Anatomical peculiarities may point to the fact that certain Miocene Apes were more nearly related than other Apes by direct affiliation to Man's ancestors. But this does not convert the former into members of the Hominidae, even if they are on the direct line of ancestry.

In his admirable review of Dr. Pilgrim's memoir Professor Boule refers to the fact of first importance that is revealed by the discoveries in India. During Miocene times Asia was inhabited by very numerous Anthropoid Apes exhibiting characters diverging in all kinds of directions, and even, as in *Sivapithecus*, in the direction of Man.

> 'Il y a là un mouvement de vie chez les Primates tout à fait extraordinaire, et l'on a, pour la première fois, la sensation que l'Asie était, à ce moment, le laboratoire où devait s'élaborer la différenciation des ancêtres des Hominiens.' (*Op. cit.*, p. 410.)

In the foot-hills of the Himalayas in Miocene times were found Apes akin to the Orangs and the Chimpanzees, to the Gorillas and Man, as well as other phyla that became extinct, after wandering east and west. The domain of the Anthropoid Apes extended as far west as Spain and Africa and as far east as Borneo. Within this widespread area these Apes, including Man's ancestors, roamed about for vast ages before Man himself appeared upon the scene. And the wanderings did not cease when real men appeared. Man's heightened powers of discrimination and adaptation made it possible for him to extend his wanderings into all kinds of country and climate, whereas the Apes were tied down to forests and tropical temperatures. When or where the Human Family came into existence is quite unknown. Man's nearest simian kindred are represented probably by the Gorillas and Chimpanzees, now restricted to Africa. But their allies ranged in

Miocene and Early Pliocene times also from Europe to India. The extinct Ape *Dryopithecus*, about as big as its nearest kindred, the Chimpanzees, ranged from Western Europe to India; and, as Dr. W. K. Gregory has recently demonstrated, it revealed a closer likeness to Man's structure than any living Ape. The Ape recently found in South Africa, which Professor Dart has named *Australopithecus*, shows even more definite signs of affinity to Man's ancestors.

The earliest known member of the Hominidae is *Pithecanthropus*, whose ancestors wandered east to Java as the Orangs and Gibbons had probably done before them. But a review of all the facts suggests as the more probable interpretation that this Ape-Man was not the original parent of the Hominidae nor Java their home, but that it was aberrant alike in structure and habitat.

The chief reason for making this claim is that the Piltdown Man was living in England early in the Pleistocene—possibly even as a contemporary of *Pithecanthropus* in Java—and he represents a type that is so different and so much more highly developed as to compel us to look upon the Javan Ape-Man as the survivor of a much earlier type, which was left behind when the ancestors of *Eoanthropus* were progressing.

In virtue of the changes that converted the Ape into Man, his powers of adaptation to changes of country, climate, and food were enormously increased. Hence he was able to spread abroad more quickly and roam into climates and into lands which were closed to the tropical forest-dwelling Anthropoid Apes. It is possible that the Taungs Ape (*Australopithecus*) had already become emancipated from the need for forest conditions. But Man was able to make his way into every region of the earth. It is important not to forget that Man has been a wanderer ever since he came into existence, and that a diffusion of culture has been effected by this means ever since he set out from his original home.

I have already insisted upon the fact that the primary and fundamental distinction between Man and the Apes was due to the growth of the brain. If one analyses the nature of the contrast between the brain in the Chimpanzee and Gorilla on the one hand and the most primitive member of the Family on the other, one of the outstanding features distinctive of the human status will be found to be primarily a great expansion of the region of the cerebral cortex that is interposed between the areas into which impulses from the visual, auditory, and tactile organs are poured (Fig. 13).

This means presumably that a greatly enhanced power of recording the impressions of these senses and of profiting by experience—in other words, an enormous expansion of the powers of discrimination based upon acquired knowledge—is the fundamental distinction between Primitive Man and the Apes. If we test this assumption by comparing with the behaviour of Chimpanzees the actions of those small isolated groups of primitive men who for one reason or another have been shielded from the effects of contact with the more progressive peoples, it becomes clear that, so far as his instincts and emotions are concerned, there is little essential difference between Man and the Apes. But in virtue of his enormously heightened powers of discrimination and his ability to profit by experience, Man has learned to control his instincts and the expressions of his emotions to a greater degree than the rest of the mammals.

So far as one can judge, there has been no far-reaching and progressive modification of the instincts and emotions since Man came into existence, beyond the acquisition of the necessary innate power of using the more complex cerebral apparatus that he has to employ.

Perhaps the most significant result of Man's enhanced powers of discrimination was the realization of his ability to communicate with his fellows by means of speech. While still in the simian stage of development

Man's ancestors were already equipped with all the specialized muscles needed for articulate speech and the cerebral apparatus for controlling their movements, and for acquiring the skill to learn new methods of action. All that was needed to put this complicated machinery to the new purpose was Man's enhanced powers of discrimination to appreciate the usefulness of communicating more intimately with his fellows and to devise the necessary symbolism. That this is not wholly idle speculation is revealed by the fact that even in the primitive and aberrant *Pithecanthropus* there was already a noteworthy and highly significant overgrowth of the area of its cerebral cortex corresponding to the part of the modern human brain, interference with which leads to a loss of the understanding of spoken language. The same feature is revealed in a more pronounced form in the Piltdown endocranial cast, as also in those obtained from skulls of the Neanderthal race. But its presence in the earliest and most primitive member of the Human Family implies that it was one of the factors which played a significant part in the early development of Man. In fact, I think it not unlikely that the acquisition of such fuller means of communication with his fellows by vocal symbols may have been one of the essential factors in converting Man's ultimate simian ancestor into a real man. The outstanding distinctive feature of mankind is, in fact, this enormously enhanced power of conveying information to and learning from his fellows, and especially of handing on the accumulated products of the experience of one generation to those who succeed them. But it is not only the results of actual experience that are thus transmitted, but also the outcome of the attempts to explain and interpret such experiences. Thus during the long history of mankind there has grown up a cloud of traditions and beliefs, to the influence of which every human being is exposed from the day of his birth and throughout his life. This artificial intellectual and moral atmosphere

colours his outlook on life and provides him with the ready-made apparatus for interpreting his own real experiences. The range of true judgement is in fact extremely limited in the vast majority of human beings. Emotions and the unconscious influence of the environment in which an individual has grown up play an enormous part in all his decisions, even though he may give a rational explanation of the motives for many of his actions without realizing that they were inspired by causes utterly alien to those which he has given—and given without any intention of dishonesty—in explanation of them. It is the exception rather than the rule for men to accept new theories on evidence that appeals to reason alone. The emotional factor usually expresses itself in an egotistical form. The 'will to believe' can often be induced by persuading a man that he discovered the new theory of his own initiative.

I have discussed these elementary psychological principles for the purpose of emphasizing the fact that Man's mental and moral attitude is, in a large measure, determined by those primitive instincts and emotions which he shares with his simian ancestors, but also by the influence, conscious and unconscious, of the atmosphere of traditions amidst which he has grown up. At no stage of his career has he acquired highly complex and specialized instincts that impelled him to build megalithic monuments or to invent the story of the Deluge, independently of other people who do the same arbitrary things. Yet modern speculation, such for instance as Sir James Frazer adopts as the text of *The Golden Bough*, would have us believe that, without any prompting from other men, people of different races, living under the most diverse conditions, independently devise fantastic customs and beliefs that reveal identities in their most eccentric and irrelevant traits.

It would ill become me as a biologist to attempt to minimize the vast role of heredity in determining the

physical structure and the mental and moral aptitudes of every individual, and the variations in the average levels of attainment to which these hereditary qualities are subject in different races. But it is necessary to emphasize the fact that, so far as innate mental and moral characteristics are concerned, it is merely a vaguely defined and more or less generalized aptitude that is inherited, and not any special kind of ability or congenital propensity towards good or evil behaviour.

The musical genius, however great his aptitude may be to appreciate the subtle symbolism of sound and to acquire the mechanical skill for giving appropriate expression to his knowledge and feelings, could not become a musician unless he is provided with the opportunities for learning the arbitrary conventions of music that obtain in the community where he happens to live.

Fossilized Remains of Extinct Types of Men.

The discovery of the remains of the Piltdown Man is perhaps the most remarkable episode in the whole history of anthropology. For it is a very singular coincidence that this wonderful skull should have come to light in the county of Sussex, within a few miles of the place where Huxley spent the last days of a life which was largely devoted to the task of convincing his fellows that some such creature must have existed in the distant past. It represents the most primitive member of the Human Family, excepting only the ape-like Javan fossil *Pithecanthropus*, which, as I have already mentioned, some leading palaeontologists still regard, not as one of the Hominidae, but as a giant Ape. But, for the reasons that I have already given, *Pithecanthropus* was truly a member of our Family. It was provided with a brain of very small dimensions, which nevertheless was much too large to have been an Ape's.

The 'Dawn Man' of Piltdown, however, was provided with a brain that, though small, comes definitely

within the range of variation in size found in modern Man. But there are clear indications that mere volume of brain is not the only criterion of mental superiority. The parts of the organ that develop latest in ourselves (Fig. 29) were singularly defective in *Eoanthropus*. Associated with the apparently human brain-case was a jaw that at first sight seemed to be as definitely simian.

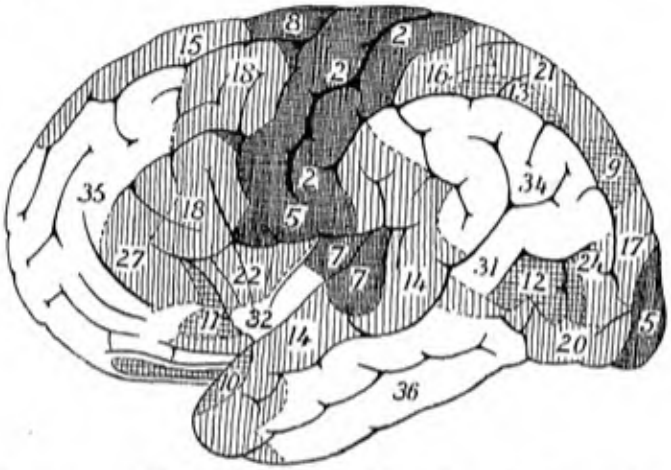

FIGURE 29. Flechsig's diagram of the left cerebral hemisphere of a human child to represent (by means of numbers) the sequence of maturation of the various cortical territories. The chief differences between the brains of Men and Apes and between *Homo sapiens* and the various extinct species and genera affect mainly areas 34, 35, and 36, corresponding respectively to *P*, *F*, and *T* in Figure 13.

The outstanding interest of the Piltdown skull is the confirmation it affords of the view that in the evolution of Man the brain led the way. It is the veriest truism that Man has emerged from the simian state in virtue of the enrichment of the structure of his mind. It is singular that so much biological speculation has neglected to give adequate recognition to this cardinal fact. The brain attained what may be termed the human rank at a time when the jaws and face, and no doubt the body also, still retained much of the uncouth-

ness of Man's simian ancestors. In other words, Man at first, so far as his general appearance and 'build' are concerned, was merely an Ape with an overgrown brain. The importance of the Piltdown skull lies in the fact that it affords tangible confirmation of these inferences. But though it is justifiable to refer to the human characters of the brain, it presents very primitive features that are of special interest. To the consideration of these I shall refer in the next chapter.

Not long after Piltdown Man made his way into England—or according to some writers even before he did so—another member of the Hominidae invaded Germany. All that is known of him is the massive brutal jaw found in the Mauer sands near Heidelberg. In spite of its antiquity and its large proportions, the form of this mandible, and especially the teeth lodged in it, approximate much more closely to the recognized human standard than do those of *Eoanthropus*.

For a vast span of time—most palaeontologists estimate the figure at approximately half a million years, a guess that is probably short of the mark—after these two divergent human genera left their bodily remains respectively near Piltdown and Heidelberg, nothing whatever is known of the history of mankind except the evidence supplied by innumerable flint implements. When the curtain is rung up again we find Europe in the occupation of the genus *Homo*, though not of our species. For Neanderthal Man was now in possession. What was the fate of *Eoanthropus* and Heidelberg Man is quite unknown. It is claimed by some writers that Neanderthal Man is merely the modified descendant of Heidelberg Man, but the reasons given for this belief are unsubstantial and unconvincing.

It is highly probable that the Neanderthal race entered Europe from Africa by way of the Iberian peninsula.

Somewhere in Africa or Asia it was evolved from the common stock which at a much earlier period had given birth to the men of Piltdown and Heidelberg.

Since this sentence was written the discovery of the remains of a typical member of the Neanderthal species in Palestine has established the fact of its presence in Asia. The survival in Africa of a much more primi-

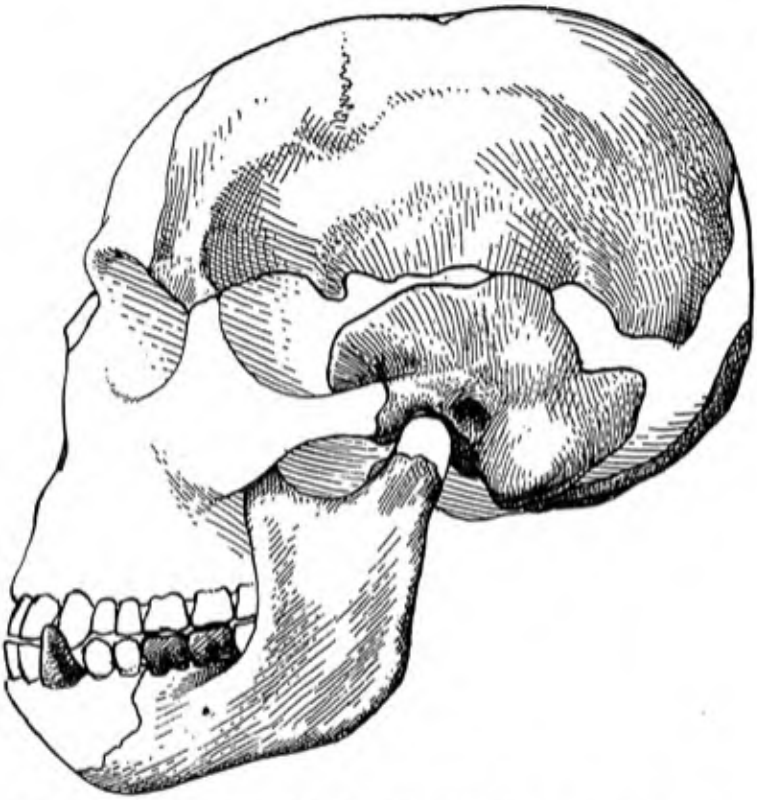

FIGURE 30. Drawing of the left side of Professor John I. Hunter's reconstruction of the Piltdown skull, by L. T. Poulton.

tive species (*Homo rhodesiensis*) revealing evidence of kinship to *Homo neanderthalensis* lends some support to the view that Africa may have been the home of the latter.

The large series of skeletal remains that have now

been recovered, and in particular the skeleton[1] found in 1908 in a grotto near La Chapelle-aux-Saints by the Abbés A. and J. Bouyssonnie, affords a clear-cut picture of the uncouth and repellent Neanderthal Man. His short, thick-set, and coarsely built body was carried in a half-stooping slouch upon short, powerful, and half-flexed legs of peculiarly ungraceful form. His thick neck sloped forward from the broad shoulders to support the massive flattened head, which protruded forward, so as to form an unbroken curve of neck and back, in place of the alternation of curves which is one of the graces of the truly erect *Homo sapiens*. The heavy overhanging eyebrow-ridges and retreating forehead, the great coarse face with its large eye-sockets, broad nose, and receding chin, combined to complete the picture of unattractiveness, which it is more probable than not was still further emphasized by a shaggy covering of hair over most of the body. The arms were relatively short, and the exceptionally large hands lacked the delicacy and the nicely balanced co-operation of thumb and fingers which is regarded as one of the most distinctive of human characteristics.

The contemplation of all these features emphasizes the reality of the fact that the Neanderthal Man belongs to some other species than *Homo sapiens*.

Many recent writers have been puzzled to account for the great size of his brain, seeing that the average capacity of the Neanderthal cranium exceeds that of modern Europeans. But, as I shall have occasion to point out later on, the development of the brain of Neanderthal Man was partial and unequal. The part of the organ which plays the outstanding part in determining mental superiority was not only relatively, but actually, much smaller than it is in *Homo sapiens*. The large size of the Neanderthal brain was due to a great

[1] A masterly account of these remains and their significance has been given by Professor Marcellin Boule in the *Annales de Paléontologie*, 1911, 1912, and 1913. See also his book *Fossil Men* (English translation of *Les hommes fossiles*), London, 1923.

development of that region which was probably concerned primarily with the mere recording of the fruits of experience, rather than with the acquisition of great skill in the use of the hand and the attainment of the sort of knowledge that comes from manual experiment.

The discovery of this species thus revealed the former existence of a type of mankind which, in spite of its great size of brain, is clearly on a lower plane than its successors whom it is customary to include within the genus *sapiens*.

The discovery in 1921, at the Broken Hill mine in Northern Rhodesia, of a hitherto unknown species of Man is an event of peculiar importance to the student of the early history of the Human Family and its wanderings. The addition of one more to the two or three species of the genus *Homo* with which we were previously acquainted is in itself a noteworthy incident; but its interest is enormously enhanced by the bizarre features of the newly discovered member of our family, and the fact that the continent of Africa, famous among the ancients as the purveyor of surprises—*semper aliquid novi ex Africa*—has at last begun to reveal some of the secrets of her extinct types of mankind, which she has so closely guarded in the past.

The Broken Hill of Northern Rhodesia has attracted considerable attention from 1907 onward, in spite of the inaccessibility of the locality, which is some 300 miles north of the Zambezi. Mr. Arthur E. V. Zealley gave an interesting account of the mine and its history to the South African Association for the Advancement of Science in 1912, from which I quote the following statement: 'Few localities in the world can be of such interest to the mineralogist as these remarkable deposits of lead, zinc, and vanadium. The variety and the extreme beauty, no less than the rarity, of several of the minerals render its study immensely attractive, and the unique association of mineralized bones, the implements, and other evidences of human occupation

of the caves in the deposit further increase the interest in the mines that have been opened up.'

In the year 1907 Messrs. F. P. Mennell, E. C. Chubb, and Franklin White called attention in several journals[1] to the evidence of early human occupation afforded by the stone implements and the broken and worked animal bones in the caves. But although hundreds of tons of animal bones had been removed from the mine since then, no human bones were seen until the summer of 1921, when parts of the skeletons of two human beings were found.

Before mining operations began at Broken Hill there stood, on the spot where the open quarry-like excavation is now found, what the Dutch colonists call a kopje (or hillock), nearly sixty feet high, tunnelled from west to east by a natural cave more than 120 feet long, the walls and roof of which consisted of dolomite and silicate of zinc; while on the floor was piled up, to a height varying from four to twelve feet, a vast collection of animal bones, so strongly impregnated with the salts of zinc and lead as to be worth mining. Many hundreds of tons of these bones had been taken out of what for fifteen years has been famous as the 'Bone Cave', and put into the smelters, along with the mineral deposits found in the kopje itself, which has now been demolished; and the excavations had been carried down 90 feet below ground-level. In the course of this work the blind end of the Bone Cave was reached and the human remains found.

If it were not for the fact that originally there had been a cleft in the roof of the cave just above the place where the skull was found, we might have drawn the conclusion that the men or women whose bones were found in the depths of the cave had already met their death before the Hyenas made it a dining-hall and began the accumulation of the vast collection of animal bones, which represents the work of, perhaps, many centuries. But the cleft does leave open the

[1] See especially *Geological Magazine* for October 1907, p. 443.

possibility of the human beings having fallen into the cave at a more recent period. However, the fact that all the bones which have been examined represent animals of species that are still alive in Africa shuts out any possibility of determining the age of the human remains. In addition to this, the incrustation of the surface of the human bones with salts of zinc and lead has protected them from the action of the soil, so that, in the strict sense of the term, they are not fossilized. Although the bones are not mineralized or, strictly, fossilized, the custom of human palaeontologists makes it not incorrect to refer to these bones as 'fossils'. If the investigator is grateful for this protection of the texture of the bony remains, he has to lament the absence of even the slightest indication of their age, which the state of fossilization might have afforded, had the circumstances been other than they were.

The upshot of all this is that the condition of the human remains and the remarkable circumstances under which they were found do not give us a scrap of information as to the date, either absolutely or relatively to other human fossils, when the Rhodesian species of Man lived and became extinct. To determine his place in the Human Family, we are thus thrown back entirely on inferences from the anatomy of the remains themselves.

The bones that have been recovered consist of the almost complete skull (without the lower jaw), a sacral bone and tibia, and the two ends of a femur, and a small fragment of the upper jaw of a second individual of the same type. According to Mr. William L. Harris, a metallurgical chemist employed at the mine, who saw the human remains when they were first brought to light and photographed them in the place where they were found, practically the whole skeleton was discovered, and was encased in a metallic cast of the surface of the body; but the Negro miners destroyed most of the bones and broke up the cast, which would have been a unique and invaluable record of the

actual bodily form and proportions of an extinct type of mankind. The skull is that of a comparatively young adult who had suffered severely from dental caries.

It was Mr. Harris, whose account of the Bone Cave and kopje I have quoted above, who communicated to the *Sunday Times* of Johannesburg the first account (September 25, 1921) of the finding of the Rhodesian Man. He also sent to a well-known European Press Agency his collection of photographs of the skull, and a very lucid and intelligent account of their significance: but it is a dramatic illustration of the lack of knowledge and appreciation of simple anthropological facts, that even so startling an object as the grotesque face of this fossil made no impression on the mind of one of the leading disseminators of information to the world at large; for he returned Mr. Harris's manuscript and photographs, with the comment that he had no use for them.

I have referred especially to this remarkable incident because it helps us to understand the dangers to which priceless remains of early types of Man are exposed, unless by happy chance some enlightened man is on the spot to save them from destruction. For this reason, it is incumbent on those who appreciate the tremendous significance of such relics to neglect no opportunity of educating the public to realize the meaning of human palaeontology, and to understand the importance of rescuing the rare fragments of extinct forms of the Human Family, which may be found by accident, and through ignorance be lost again for ever.

I have already explained that the circumstances under which the Rhodesian remains were found afford no indication, not the merest hint, of their age or the place of their possessor in the Human Family. Any inference that attempts to settle these problems must, therefore, be based upon the features of the bones themselves.

The obtrusive fact, which no one can fail to notice, is the appearance of the face, revealing as it does a form that has never been seen before. It is certainly the most primitive type of face that is known among members of the Human Family. But in making this statement I must guard against a misunderstanding that has repeatedly arisen in the discussion of the Rhodesian skull. In referring to it as the most primitive human *face* at present known, I do not mean to suggest that the Rhodesian *skull* is the most primitive type of human being so far recovered. Two members of the Human Family are known from fossilized remains, found in Java and England respectively, that are vastly older than the Rhodesian Man, and so profoundly different from all other members of the family that they are not included in the genus *Homo*—the new genera, *Pithecanthropus* (Dubois) and *Eoanthropus* (Smith Woodward), respectively, having to be instituted for their reception. But the face of neither of these fossils has been recovered, although the possession of the lower jaw of *Eoanthropus* makes it possible for us with confidence to restore the general form of the face.

This, however, does not affect the accuracy of the statement that the Rhodesian skull provides us with the most primitive example of an actual human face—and a most remarkable one it is. It is more definitely primitive and brutal than that of any other human being, living or extinct, that is at present known. The enormous eyebrow-ridges are bigger, even, than those of the most archaic member of the Human Family, the Javan Ape-Man; and in the extent and form of their lateral extensions they recall the condition found in Man's nearest simian relative, the Gorilla.

There is no groove at the side of the nose, to indicate the boundary between it and the face, such as one finds in all races of modern men, even in such flat-nosed individuals as the Negro, the Mongol, and the aboriginal Australian. This merging of the nose

in the face, to form what, in other animals, would be called a snout, is a peculiarly significant mark of the beast, which is known elsewhere in the Human Family only in the extinct fossil species from Europe known as Neanderthal Man. But the nose of the Rhodesian Man was definitely more Ape-like than that of Neanderthal Man. The lateral margins of the nasal aperture extend vertically downward, towards the teeth, as

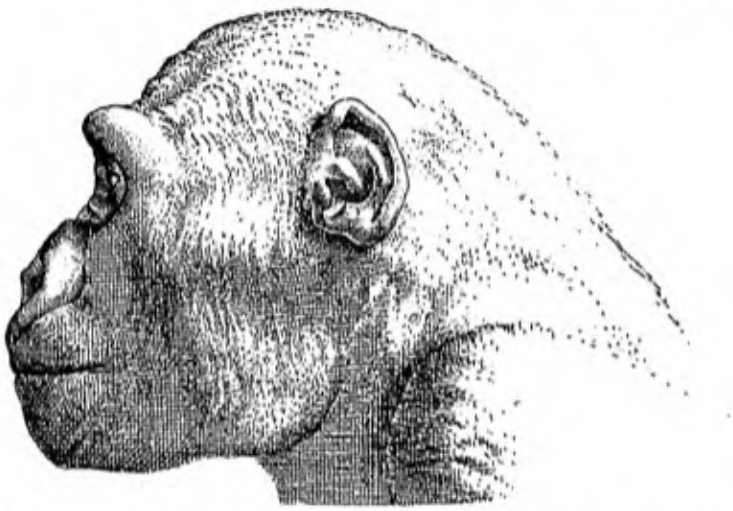

FIGURE 31. The profile of a Gorilla to show the nasal cartilages, such as are found in Man but in no other Ape (from a photograph by Professor James H. McGregor).

happens also in the Gorilla, in which this arrangement is associated with the widely outsplayed margins of the nostrils supported by alar cartilages (Fig. 31) like those of the human nose, but not found in any other Anthropoid Ape, that is so distinctive a feature of Man's nearest simian relative. Perhaps also the Rhodesian Man had a wide nose, in comparison with which the Negro's or the Tasmanian's would seem narrow. Yet the presence of a nasal spine on the Rhodesian jaw indicates that, in spite of the simian resemblances in the nose, it had the distinctively human features of a

horizontal edge of the nasal septum and a definite tip to the nose.

Another remarkable feature of the enormous facial skeleton is the vast size of the palate and teeth, and especially the extent of the interval between the nose and the margin of the upper jaw. Although the jaw is so extensive and the teeth so large, the canine teeth did not project in the Ape-like manner of those of Piltdown Man (*Eoanthropus*) and the fossilized proto-Australian found at Talgai in Queensland.

The form of the brain-case and the peculiarly distinctive features of the brain that it once contained corroborate the inferences drawn from the face, that the Rhodesian species was the most primitive member of the genus *Homo* at present known: but not the most primitive of the Human Family, which of course includes the vastly more ancient and lowlier genera, *Pithecanthropus* and *Eoanthropus*. The long straight shin-bone and the fragments of the femur afford a very clear demonstration of the fact that Rhodesian Man is separated by a very considerable hiatus from his nearest relative, the extinct European Neanderthal Man. But I must defer the reference to this until a later page.

The bones found in Rhodesia, however, have a far wider and deeper significance to the student of mankind than these statements suggest. The recovery of a long-lost and strangely exotic cousin is an experience that excites our curiosity; and the opening-up of a new continent for the human palaeontologist awakens visions of what this ancient domain of the Human Family may provide for future anthropologists. But the immediate problems that the study of the features of the skull and limb bones brings up for discussion involve comparisons with all the other types of mankind, and a comprehensive testing of the opinions previously put forward to interpret the significance of all the fossil remains of Man and their bearing on the history and migrations of the Human Family.

A newly discovered species comes to have value and importance only when the effort is made to put it in its proper position in its family, and to determine the part it played and the light its structure and associations throw upon mankind as a whole. In an attempt such as this to interpret the significance of the new discovery, it is necessary, above all else, to define

FIGURE 32. Left side of Rhodesian skull, drawn by] T. L. Poulton. × ½.

this setting—our present knowledge of the family circle of the *Hominidae* into which a long-lost cousin has to be introduced and assigned his appropriate place. Hence the discussion of the significance of the newly found fossil must inevitably involve some reference to the history of mankind as a whole.

The few broken fragments of these extinct members of the Human Family which have so far been recovered probably represent only a small minority of the many experimental types discarded by Nature before she

succeeded in fashioning the supreme species capable of outstripping the rest in the competition for intellectual supremacy. Without undue modesty, we who belong to that species have labelled it *sapiens*.

The vast continents of Africa and Asia represented (or perhaps it would be more correct to say that one or both of them included) the domain of Primitive Man during the early history of the Human Family, and the laboratory in which, for untold ages, Nature was making her great experiments to achieve the transmutation of the base substance of some brutal Ape into the divine form of Man. Until the Rhodesian remains came to light, no fragment of an extinct type of Man had come from Africa; and Asia had provided, from Java—which, at the end of the Pliocene Period, was the extreme south-eastern corner of the vast continent—the fragments of one skeleton, *Pithecanthropus*, the most archaic member of the Human Family. But no trace whatever of human remains has yet been found in the central Afro-Asiatic area, the real cradle of the family. Only the broken fragments swept out to its periphery, Far-Eastern Asia, South Africa, and Western Europe, have so far been recovered, to give us some slight clues as to what was happening in the really vital spot.

The vast geographical area that separates Java from Europe, and the incalculable span of time that intervened between the epochs of *Pithecanthropus* and all the fossil men of Europe (excepting *Eoanthropus*), represent a tremendous hiatus in the early history of the Human Family. Behind the veil of all these hidden centuries, it is well within the bounds of reasonable conjecture to picture the wide stretch of Southern Asia and Africa as peopled by a variety of weird caricatures of mankind, roaming far and wide to satisfy their appetites and avoid extinction. In this competition, the distinctive characters of Man were fashioned in the hard school of experience. All that we can learn of the tremendous drama that was being enacted in this laboratory of man-

kind is based on inferences from a skull-cap and femur from Java, a skull and tibia from Rhodesia, and an assortment of bones from Western Europe!

But if we know nothing of the wonderful story of Man's journeyings towards his ultimate goal, beyond what we can infer from the flotsam and jetsam thrown up on the periphery of his ancient domain, it is essential, in attempting to interpret the meaning of these fragments, not to forget the great events that were happening in the more vitally important central area—say from India to Africa—and whenever a new specimen is discovered, to appraise its significance from what we imagine to have been happening elsewhere, and from the evidence it affords of the wider history of Man's ceaseless struggle to achieve his destiny.

Nature has always been reluctant to give up to Man the secrets of his own early history, or, perhaps, unduly considerate of his vanity in sparing him the full knowledge of these less attractive members of his family, who too obviously retained the mark of the beast.

Thus, during the thousands of years after the members of our species came into being, they remained in ignorance of the fact that, before the species *sapiens* emerged, the earth was occupied by other species and other genera of mankind. In fact the first fragment of one of these other species was found at Gibraltar in 1848; and not until many years afterwards was the momentous significance of this discovery (as the recovery of the representative of the hitherto unknown species *neanderthalensis*) appreciated.

The finding of a female skull in 1911 at La Quina, not only of the same species, but also of the same race, as the Man from the Neanderthal cave, shows that the difference between the La Quina and the Gibraltar women is something more than a mere sexual distinction. For there is a marked contrast between the forms of the two female skulls from La Quina and Gibraltar respectively, and the latter is definitely the more primitive of the two. But there is no justification

for reviving the old and discarded name *Homo calficus*, suggested by Falconer, or for following the Italian anthropologist, Sera, in regarding the Gibraltar woman as the sole representative of a species distinct from (and more primitive than) the true Neanderthal species. It is more in accordance with the evidence to regard the Gibraltar fossil as a member of the Neanderthal species, but as belonging to a different and more primitive race (the Calfic) of that species. It has just (July, 1926) been announced, however, that Miss Garrod of Oxford has found at Gibraltar the remains of a second skull of the same type as the original specimen. It is said to have been found in association with Mousterian implements, so that it belongs to the same phase of culture as Neanderthal Man.

I have entered into this question because the fact of the discovery of the most primitive member of the Neanderthal species at the very threshold of Europe, near the chief gateway from Africa, is not without significance in the discussion of the Rhodesian skull, which may represent a persistent survivor in Africa of the type of Neanderthal Man's ancestor, possibly nearly akin to Heidelberg Man.

The outstanding feature of the Rhodesian Man's traits is the suggestion of a half-developed Neanderthal Man, with some of his peculiarities grossly exaggerated, while others are lacking, or replaced by primitive features that more nearly approach the type of modern Man.

When Charles Darwin discussed the evolution of Man, he was inclined to regard Africa as the likeliest place for the original home of mankind. It is generally recognized that the two African Anthropoid Apes, the Gorilla and the Chimpanzee, are more closely akin to the Human Family than the other anthropoids, the Orang and the Gibbon, whose geographical domain is now restricted to the Far East; and it seemed to be more likely than not that, in the migrations of Man's nearest relatives from their birthplace, perhaps in

Northern India, ancestors of the Human Family may have accompanied those of the Gorilla and Chimpanzee when they made tropical Africa their home. These, however, are mere conjectures that future discoveries may or may not confirm. But with regard to the Anthropoid Apes themselves, the fossil remains of the little *Propliopithecus*, found in the Egyptian Fayum ten years ago, reveal the fact that, ever since the Anthropoid Apes first came into existence (probably at the end of the Eocene Period), Africa has been a part of their domain, if it was not their original home.

I call attention to these considerations, to suggest that the evidence now at our disposal affords some slight justification for the speculation that Africa may have been the area of characterization, or, to use a more homely phrase, the cradle, both of the Anthropoid Apes and of the Human Family. In any case, it is probable that Africa played an important part in the early history of Man and his ancestors.

But hitherto no fossilized remains of early types of Man have come to light in Africa, to substantiate these assumptions. Some months before the declaration of war in 1914, the announcement was made of the finding of a fossil human skull at Oldoway, in what was then German East Africa; but from the imperfect accounts that have so far been given it seems that this type of Man does not differ from the African Negroes of the present time. A much more important discovery of fossilized human remains was made a year earlier (in 1913) at Boskop in the Transvaal. The Boskop Man cannot be regarded as a member of any of the races still living in Africa; but I think he belongs to the species *Homo sapiens*, and in some respects is akin to the earliest members of that species found in Europe, often called the Crô-Magnon race. Dr. Robert Broom is so impressed with the peculiar features of this skull that he suggests the creation of a new species, *Homo capensis*, for its reception.

Investigation of the extinct peoples of Europe has

directed attention to the probability that the earliest members of the Human Family found in Western Europe must have come there from Africa.

For various reasons, in addition to the fact that the Bushmen, Hottentots, Pygmies, and other Negroes are among the most lowly races of mankind, Africa is eminently the place where one might expect to discover the remains of still more primitive types of the Human Family.

The peculiarities of the Rhodesian discovery are not exhausted by the statements that the skull reveals a hitherto unknown type of face and skull, and represents the first traces of a species other than *Homo sapiens* from Africa. For the circumstances under which they were found, and the condition of the remains, are altogether different from those of any of the other famous discoveries of fossilized remains of Man. The peculiarities of these circumstances I have already explained.

The claim that Rhodesian Man is more primitive than Neanderthal Man does not necessarily imply that the individual whose remains were found at the Broken Hill mine was alive in the remote times of the Glacial Epoch in Europe or had not survived to a period ages later than the period of the fossil men of Gibraltar, Neanderthal, and the Dordogne Valley. The animals with which Neanderthal Man was associated in Europe became extinct there when that type of Man disappeared from Europe: but many animals closely akin to them are still living in Africa; and it is quite conceivable that an early type of Man also may have survived in Africa, as the Elephants, Rhinoceroses, Hippopotamuses, and Hyenas have done, for many centuries after their European relatives had been wiped out of existence. It may have happened that the Rhodesian species lived on in South Africa, free from human competition, until the Boskop race, or the ancestors of the Bushmen, made their way down the Dark Continent.

So far, I have referred only to the face of Rhodesian Man, and the very positive evidence it affords of the primitive (that is, definitely pre-Neanderthal) type. It has been claimed that such an inference is rendered untenable by the characters of the brain-case and the leg-bones. Let us consider the question thus raised for discussion.

The features of the skull, according to some writers, more closely resemble those found in *Homo sapiens* than those of *Homo neanderthalensis*. Hence certain distinguished authorities have suggested that Rhodesian Man is a later modification of Neanderthal Man, or intermediate in type between it and *Homo sapiens*. Even if the primitive characters of the face of the Rhodesian skull were not fatal to such an argument, it would not be convincing, because it does not take into account the fact that, in many respects, the skull of Neanderthal Man is highly specialized and farther removed from the primitive condition than modern Man's skull is. The particular features of resemblance of the Rhodesian and modern skulls are precisely the primitive features that the Neanderthal Man lost through early specialization. Just as the Gorilla and the other Apes became differentiated from Man's ancestors by acquiring specializations of habit and structure, which destroyed many primitive features retained in the living members of the Human Family, so the dominant species of the latter has retained many primitive characters that were modified or lost by his unsuccessful Neanderthal cousins. But the possession of such traits by the more primitive members of the Family does not mean that the latter are post-Neanderthal in time and development. Its significance is quite the reverse: these primitive characters have been lost by Neanderthal Man, never to return, either in them or any forms derived from them.

But, quite apart from this consideration, the brain-case of the Rhodesian skull does retain a number of characters definitely more primitive than those of

either *Homo sapiens* or *Homo neanderthalensis*. This is not the place to discuss the technical details of these anatomical features, which are most strikingly displayed in the architecture of the base of the skull. But there is one aspect of the study of the brain-case to which attention must be called, because it is of fundamental importance in the interpretation of Rhodesian Man's peculiar significance. The skull provides precise information concerning the size and general form of the brain and its various parts, which has a very direct bearing on the determination of the rank of its possessor in the hierarchy of the Human Family.

This evidence will more readily be appreciated if the cast of the brain-case of Rhodesian Man be compared with those of the two most primitive members of the Human Family (Fig. 33).

No one who has seen the cast of the interior of the brain-case, and is capable of interpreting its obtrusive peculiarities of form and proportions, could have any hesitation in deciding that *Pithecanthropus* was truly a member of the Human Family, if a very lowly one. The capacity of the brain-case of the Javan specimen was probably about 950 cubic centimetres (that is, about 100 cubic centimetres greater than Professor Dubois's estimate), which brings it within the range of variation even of *Homo sapiens*; whereas 650 cubic centimetres is the biggest record for an Ape, even of a Gorilla twice the body-weight of a human being.

The endocranial cast of *Pithecanthropus* reveals a localized and precocious expansion of those areas of the brain which we associate with the power of articulate speech, that is, ability to appreciate, in a far greater degree than other animals are capable of, the auditory symbolism of sounds, and to reproduce them as a means of communication with its fellows, not merely as signals expressive of emotional states, such as most animals can impress upon one another, but also as the means for transmitting information and ideas, and attaining the communion of knowledge and belief

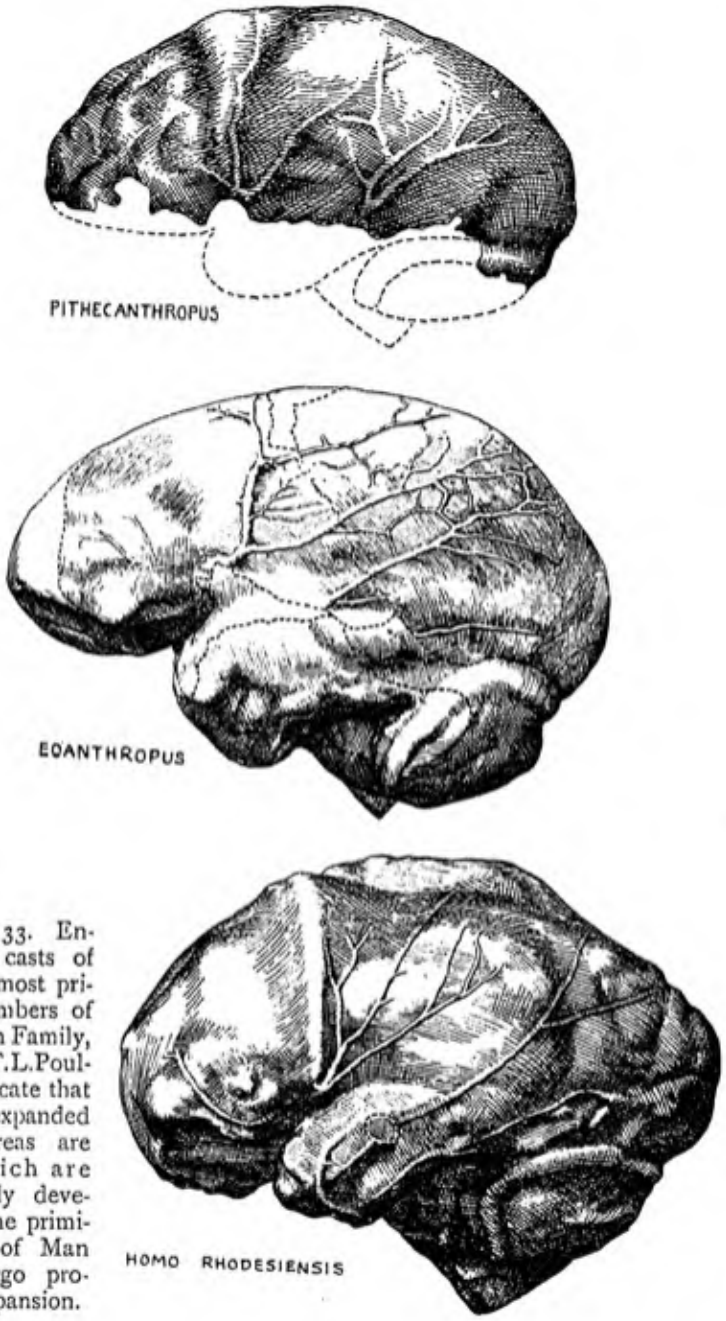

FIGURE 33. Endocranial casts of the three most primitive members of the Human Family, drawn by T.L.Poulton, to indicate that the newly expanded cortical areas are those which are most feebly developed in the primitive type of Man and undergo progressive expansion.

that is Man's exclusive prerogative. There are grounds for believing that the acquisition of true articulate speech was one of the essential factors in the emergence of Man's distinctive characters; and the form of the endocranial cast of *Pithecanthropus* suggests that the Javan Ape-Man possessed this hall-mark of human rank, and the right to be included in the Human Family.

The same distinctive features are recognizable also in the somewhat larger endocranial cast of *Eoanthropus*, the Dawn-Man of Piltdown. Special interest attaches to its features because it affords a certain amount of information as to the size, form, and relative development of the brain of a very primitive type of mankind, perhaps the immediate ancestor of the genus *Homo*. The prefrontal, central parietal, and inferior temporal areas are very defective; but the most distinctive feature of the cast is the wideness of the gap between the frontal and temporal areas, an objective demonstration of the exceptionally poor development of both. In spite of this there are indications of a greater (localized) development of the inferior frontal convolution than there is in *Pithecanthropus* and a very obtrusive boss in the posterior temporal area (compare Fig. 46). Both of these signs of precocious expansion can be associated with the acquisition of speech. But perhaps the chief interest of the brain of *Eoanthropus* is that it forms an invaluable stage in the progressive expansion of the human brain (Fig. 33), the earlier and later chapters of which *Pithecanthropus* and *Homo rhodesiensis* respectively give us some idea. In this connexion it is important to bear in mind the conditions found in the Gorilla's brain (Fig. 13).

The peculiarites of the brain of Rhodesian Man can best be summarized by the statement that it is intermediate in type between those of the Piltdown and of the Neanderthal men. It is distinctly larger than the former, but smaller than the latter. The process of development revealed by comparing the endocranial

cast of the Piltdown skull with that of *Pithecanthropus* is carried a stage farther in the Rhodesian brain. The expansion has involved other areas ; but there are still territories in the upper parietal, prefrontal, and inferior temporal regions of the Rhodesian brain that are singularly ill-developed as compared with the corresponding parts of the brains of either the Neanderthal or the modern species of Man.

It is of special interest to note that the defective areas of the brain are those parts which attain their maturity latest in the developmental history of the modern human infant (Fig. 29), and are especially associated with the discrimination of the form, weight, and texture of objects as they appeal to the sense of touch, with the power of learning highly skilled movements with the hands, and, in a general sense, with the higher intellectual functions. The part of the brain that has been found to be highly developed in several modern men distinguished for musical genius is remarkably small, and simply folded, in the Rhodesian brain. This brain, in fact, was deficient in those parts by which the degree of foresight, discrimination, and refinement of modern men is determined and made possible.

The evidence afforded by the brain thus corroborates the inference drawn from the peculiarities of the face and the skull, that the Rhodesian Man conforms to a type definitely more primitive than that of the Neanderthal species.

But there is one feature of the remains found at Broken Hill that has raised some doubt as to the correctness of this inference. The leg-bones found with the skull are longer and straighter than the corresponding bones of members of the Neanderthal species. The short, thick, and curved leg-bones of Neanderthal Man, which distinguish this ungainly type of mankind with a shuffling gait and bent knees, are often regarded as survivals of Man's more simian ancestors. The condition of the neck vertebrae and the skull of Neanderthal

Man corroborates the conclusions drawn from the leg-bones; for they complete the picture of the slouching body by showing that the head was thrown forward on the thick massive neck. Instead of being truly erect, the body was carried in a stooping attitude, the line of the back passing, by a gradual curve, along that of the neck to the brutal flattened head.

The length and straightness of the Rhodesian leg-bones and the features of the base of the skull have been claimed as evidence that the Man of Broken Hill walked upright, and had therefore lost the mark of the Ape which survived in Neanderthal Man's posture. If the Rhodesian Man has really lost this simian trait, which Neanderthal Man has retained, how, it may be asked, can the former be regarded as a more primitive type than the latter? Is Sir Arthur Smith Woodward right in claiming that the Rhodesian Man walked erect, and represents a phase of evolution later than the Neanderthal type? These are the problems that still have to be threshed out. All that I need say on the matter now is, first, that the inclination of the base of the skull (the basioccipital slope) is not in such close agreement with that of modern Man as has been supposed; and, secondly, that the leg-bones present peculiar features which differentiate them from those both of modern Man and Neanderthal Man.

In the discussion of this extremely difficult and highly technical problem, the question of the significance of the thigh-bone found along with the skull-cap of *Pithecanthropus* will have to be threshed out once more. If the leg-bone found in the same formation as the skull at Trinil really belonged to *Pithecanthropus*, and the specific name *erectus* given to the Javan Ape-Man by Professor Dubois is a correct description of its posture, the recognition of this fact will have a very direct bearing on the estimation of the significance of the Rhodesian Man's posture. For, if the most ancient and primitive member of the Human Family walked erect, the (assumed) erectness of Rhodesian Man cannot

be fatal to the claim to regard him as primitive. In the meantime, the evidence provided by his face, brain-case, and endocranial cast, seems to me to point conclusively to the fact that, in the bones found in the Broken Hill mine, we have the remains of a type of mankind definitely more primitive than all the known members of the Human Family, with the exception only of *Pithecanthropus* and *Eoanthropus*, from Java and Piltdown respectively.

The Rhodesian remains have now found a resting-place, beside those from Piltdown, in the Natural History Department of the British Museum at South Kensington.

Early Types of Homo sapiens.

In a later Chapter of this book I shall have occasion to refer to the recent discovery in the heart of the city of London of a fossilized human skull that can in all probability be referred to the earliest Neanthropic phase of culture. It differs in type from any of the contemporary members of the species *sapiens*.

The problems raised by the discovery of the London skull can be adequately appreciated only by comparison with other early types of *Homo sapiens*.

The Talgai skull, of which my brother has given a full description,[1] is the fossilized remains of the earliest aboriginal Australian so far discovered. Nothing whatever is known of its age. Although it is completely mineralized there are no reasons for assuming that it is more than a few thousand years old. Even if, as seems not improbable, men of this Proto-Australian type reached Australia while the now extinct gigantic Marsupials were still living, that would not necessarily imply any great antiquity. The fact that Man took dogs with him may explain why and how the *Diprotodon* and its contemporary large Marsupials were wiped out of existence. Moreover, the considerations

[1] *Philosophical Transactions of the Royal Society*, 1918.

that the earliest immigrants into Australia had domesticated dogs, and that to reach the island continent they must have crossed by boats or floats of some sort at least one sheet of open sea (Wallace's Line separating Celebes from Borneo and Java), if not several such breaks, suggest a comparatively recent date for such exploits.

The Talgai skull conforms to the Australian racial type, but it is remarkable for the enormous size of its palate and teeth (especially the salient canine teeth). The size of the palate is all the more remarkable because the skull is that of an adolescent boy: thus it is safe to assume the jaw and palate would have attained even greater dimensions had he reached the adult state. Hence one is justified in distinguishing the Talgai skull from the modern Australian by the term Proto-Australian.

Professor Dubois claims to have found fossilized remains of the same people at Wadjak in Java.

There are still living in several of the islands of the Malay Archipelago and amongst the jungle tribes of India undoubted representatives of the Australian race. The earliest examples of this race in India are probably included in the collection of human remains obtained by Mr. A. Rea, of the Archaeological Department of the Madras Presidency, at Adittanallūr in the Tinnevelly Valley district. In 1912 the Director of the Madras Museum sent me two of the skulls from this series for examination. One of these is unmistakably Australoid in type (Fig. 35).

In the first volume of his *Castes and Tribes of Southern India* (1909) Mr. Edgar Thurston gives an account of these skulls and a lengthy discussion of their significance (on pages xxvi–xlii of the Introduction), with a photograph of the skull to which I have just referred. He also quotes a statement made by Monsieur L. Lapicque to the effect that he considers the race of Adittanallūr to be Proto-Dravidian. Discussing the question of age in the *Archaeological Survey of India*

Annual Report, 1902–3, page 113, Mr. Rea says we have no unquestionable, but only circumstantial evidence of dates that can be variously interpreted. Speculations as to the age have ranged from 400 to 4,000 years old, and no one can disprove either assertion, but there seems to be a possibility that the site may even have been occupied during early Pandyan times, that is at least several centuries before the beginning of the Christian era.

The two skulls that were sent to me for examination at the end of 1912 conformed to different racial types. One of them is clearly and unmistakably Proto-Australian in type, and the second one conforms more nearly to the racial type that is known as Mediterranean, which is so largely represented in the present population of India.

In discussing the Neanderthal skull the consideration has already been emphasized that the many points of resemblance between the Neanderthal species and the aboriginal Australian, who unquestionably belongs to the species *sapiens*, can best be explained if we regard the Australian as a survival of the earliest phase of the latter species with relatively slight modifications.

I have referred to this matter (and the fact that undoubted members of this race are still living as far west as India) for the purpose of directing attention to certain aspects of the problems of early Neanthropic remains in Europe. Professor D. K. Absolon, of the University of Prague, has described[1] a series of human remains and a vast collection of implements and animal remains found at Předmost in Moravia, which are now in the Museum of Brno (Brünn), of which he is Curator. He called attention to certain peculiar resemblances in the objects made by these early members of the species *sapiens* in Eastern Europe and the most primitive living members of that species in Australia. This prompts the questions whether this similarity of magical

[1] See *Illustrated London News*, 7, 14, and 21 November 1925.

usage implies a diffusion of culture, and further whether this is so ancient as to be referred back to a time when the ancestors of the Australians were living in Western Asia.

Before discussing this problem let us first consider the purely racial aspect of the questions involved. The people who dwelt in Europe after the disappearance of Neanderthal Man and before the beginning of the Neolithic Phase do not conform to one racial type.[1]

The Aurignacian Crô-Magnon people are generally believed to belong to a race different from the Early Aurignacian remains found in the Grotte des Enfants at Mentone—a difference which Dr. Verneau has emphasized, perhaps unduly, by calling the latter 'negroid' and inventing the term 'Grimaldi Race' as a designation for them. Then there is a third Aurignacian type represented by the skeleton found at Combe Capelle, which is commonly believed to differ in race both from the Crô-Magnon and from the 'Grimaldi' remains. Then there is the London skull, which differs from the other three Aurignacian types. The Solutrean levels reveal a type often known as the the Brünn Race, including human remains from Brüx, Brünn, and Předmost in Moravia. Although not identical in every respect with the Combe Capelle type from the French Aurignacian, the latter is often included in the so-called Brünn Race. Coming to the later period (Magdalenian) yet other types are revealed. Of these the Chancelade and Oberkassel skulls have been the subjects of lively controversy, different writers claiming either or both of them to be Eskimo, Crô-Magnon, Nordic, or some other race!

I do not propose to discuss these highly contentious issues. All that I shall attempt to do is to

[1] A useful and suggestive discussion of the 'Relationships of the Upper Palaeolithic Races of Europe' by the late Dr. Louis R. Sullivan is to be found in *Natural Science*, 1924, p. 682. His interpretation of the evidence is not in complete agreement with that suggested here, but it puts another point of view with great lucidity and wealth of illustrative material.

discover what light these remains shed upon the problems of the origin and history of *Homo sapiens*.

The view expressed by Dr. René Verneau (*Les Grottes de Grimaldi*, Tome ii, Fascicule i, 1906) has been widely accepted. He claimed that two skeletons found in the Grimaldi Cave known as the Grotte des Enfants are the remains of an old negroid woman and a youth between 15 and 18 years of age.

During the last week in December, 1925, Monsieur Léon Labande, the Director of the Musée d'Anthropologie Préhistorique at Monaco, courteously permitted me, in company with Mr. W. J. Perry, of London, and Professor J. H. McGregor, of Columbia University, New York, to examine these skeletons, and we were fortunate in having the assistance of Monsieur F. Lorenzi, who, more than twenty years ago, did most of the work of excavating the Grotte des Enfants under the direction of Canon de Villeneuve. With reference to the so-called old woman I was somewhat surprised to find that the sagittal suture was visible in the whole of its extent, and so far as I could discover showed no sign of closing. The same remark applies to the lambdoid suture: but in the case of the coronal suture the skull was encrusted with reddish earth and with cement-like material, which had been applied by Dr. Verneau to strengthen the skull, so that most of this suture was hidden. It is significant, however, that wherever this encrusted material had scaled off, as it had done at the bregma and a spot midway between the bregma and the temporal line, the coronal suture was seen to be as open as the other sutures were. These facts can be confirmed in the excellent photogravures reproduced in *Les Grottes de Grimaldi* (Tome ii, Plate 5): but Dr. Verneau himself makes the following statement (page 131) with reference to this matter:

'Les sutures se montrent toutes simples. La coronale est en grande partie oblitérée, mais la sagittale et la lambdoïde, quoique très serrées et sur

le point de se synostoser, sont encore visibles dans toute leur étendue. Comme chez les races inférieures de notre époque, l'ossification des sutures a donc commencé par la région antérieure.'

Although the evidence of the sutures is not an absolutely certain indication of age in the case of any individual skull, it is altogether exceptional to find n a person as old as 30 years a skull in which there is no indication whatever of the closure of the sagittal suture. So that unless there is some very definite reason to the contrary one is not justified in assuming that the so-called old woman of Grimaldi was really old, or even as much as 30 years of age. The general appearance of the skeleton, especially the long bones of the limbs, suggests that the skeleton is that of a young woman. The only fact that gives any suggestion of old age—and that suggestion is certainly a spurious one—is the edentulous state of the molar region of the lower jaw. This condition, however, not infrequently occurs in the early twenties among primitive people who live on coarse food.

The whole problem of the value of endocranial sutures as an index of age in adults (in either sex of European or of Negro ancestry) has been very thoroughly investigated during the last couple of years by Professor T. Wingate Todd and Dr. W. Lyon, working on the magnificent collection of material which Professor Todd has been able to collect in the Hamann Museum in the Western Reserve University in Cleveland, Ohio. The four memoirs dealing with this subject have been published in the *American Journal of Physical Anthropology* for 1924 and 1925, and the authors have been able to show that neither race nor sex seems to affect the time of closure of the sutures. They have shown that in the great majority of cases the sagittal suture begins to unite at 22 years and the process of closure is complete at 31, progress being most rapid at 26 years of age. The coronal suture normally begins to close at 24 years: progress is most

rapid between 26 and 29, and thereafter the process of closure spreads very slowly, completion not being effected until 38. In the case of the lambdoid suture closure begins at 26, and although progress is rapid until 29, complete closure is unusual before 42. The authors are careful to emphasize the fact that the individual variability of the progress of suture union makes it unwise to depend too much upon the stage of closure as an age marker. At the same time they have shown that it is exceptional for a skull of 30 years to show no sign of closure, so that unless very positive evidence is forthcoming to the contrary one would not be justified in assuming that a skull in which there is no trace whatever of the closure of the sutures belongs to an individual of more than 25 or 26 years of age.

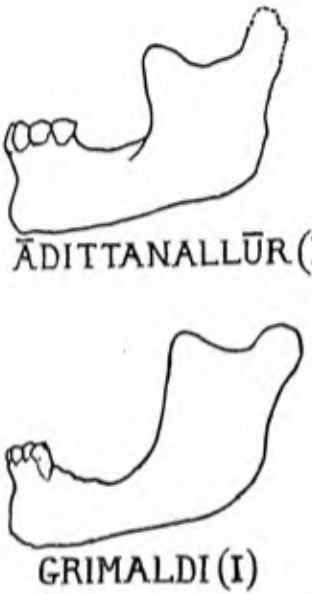

FIGURE 34. Comparison of the mandible of the so-called 'Old Woman' of the Grotte des Enfants with a young Indian jaw with a similar loss of molars.

I submit that in the case of the so-called 'old woman' of Grimaldi there is nothing to justify one in assuming that she was abnormal. The appearance of the skull and of the bones of the skeleton affords no indication of senile changes. Even if there is no arthritic change the articular surfaces of the long bones usually reveal tokens of senile changes. In the skeleton under consideration there is nothing to suggest an age of more than 30 years. In making this statement I am aware that the teeth are worn down, and that the molar series of the lower jaw has disappeared with the erosion of the alveolar process. Presumably it

is this senile appearance of the mandible that led Dr. Verneau (and all the anthropologists who have followed him) to regard the skull as old; but no one who has examined a large series of primitive skulls can fail to be aware of the fact that in people accustomed to a rough diet, especially food mixed with sand, six or seven years is amply sufficient to wear the teeth down level with the gums and to produce alveolar abscesses which lead to the shedding of the teeth and erosion of the jaw. It is not by any means uncommon for this to happen long before the age of 30 is reached. Curiously enough, in one of the Indian skulls from Adittanallūr we have precisely the same combination of characters as are found in the so-called old woman of Grimaldi. The cranial sutures show no trace whatever of closure: yet the molar series in the lower jaw has disappeared and the alveolar process has been absorbed (Fig. 34).

Next, with regard to the age of the so-called youth (which was estimated by Dr. Verneau as being between 15 and 18): the second premolar teeth, which normally appear at 11 or 12 years of age, are still in process of eruption. The left upper canine, which normally appears at from 11 to 12, is also unerupted; but in favour of the later of these possible dates one must take into consideration the fact that the second molars, which normally appear at 12 or 13 years of age, are fully erupted in both jaws of this individual, which raises a possibility that he may be, and probably was, as old as 13 years. But there is nothing either in the condition of the teeth or in the long bones to justify the conclusion that the youth was much more than 13 years of age. The presence of hard cement-like material applied to the long bones to fix the epiphyses makes it difficult to be certain of their exact condition: but there is nothing that I can discover in the condition of the epiphyses to justify the conclusion that this youth was much more than 13, or at the most 14 years of age. It will be obvious then that he was not fully

grown, and would eventually, had he lived, have attained a much greater height than was the case at the time of his death. His height was greater than that of the average stature of the modern youth of corresponding age. Hence the argument that has been used on the basis of the small size of this youth is entirely misleading and fallacious.

This new estimate of the ages of the woman and child from the Grotte des Enfants does not necessarily affect the assumption that they may possibly be the remains of a mother and child—for there is no reason why a woman 30 years of age might not have been the mother of the boy of 13.

Racial Characters of the Grimaldi People.

Discussing the significance of these two skeletons, Dr. Verneau expressed the opinion that their physical peculiarities presented striking analogies to the distinctive characters of Negroes, and eventually came to the conclusion that these two skeletons were the remains of people who were negroid, if not definitely Negroes. In support of this conclusion he cites the proportions of the limbs and the characters of the head, and especially the face. The importance of the great relative length of the forearm and of the leg below the knee as evidence of Negro affinities is neutralized by the fact that the Crô-Magnon people, whom no one claims to be negroid, present this same peculiarity.

Turning to the consideration of the face, one finds that the formation of the nose and forehead, of the orbits and jaws, present a much closer likeness to those of the Australian race than they do to Negroes. In this connexion it is not without interest to note that in his important monograph on the teeth of the youth from the Grotte des Enfants Professor Albert Gaudry (writing in *L'Anthropologie*, 1903, Tome xiv, as well as in the volume *Les Grottes de Grimaldi*, pp. 137–44) finds closer analogies in the form and proportion of the very large teeth of Australians than in those

of other skulls. In his book *Fossil Man* (1923) Professor Boule accepts Dr. Verneau's interpretation, and even goes farther and insists upon the close similarity between the structure of the skull, and especially the jaw, in the Grimaldi people and those of modern Bushmen, a view that Dr. Verneau himself utterly repudiates.[1] But no one who studies the formation of the skull in primitive members of the Mediterranean race, such for example as the Predynastic Egyptians, or in such skulls as the two early specimens from India to which I have referred earlier in this Chapter, can fail to admit that the formation of the jaw is much nearer to the latter two groups than it is to that of any Negro people. These remarks apply also with special force to the form of the nose, and the especial distinctive type of the root of the nose. Professors Verneau and Boule call special attention to the breadth of the root of the nose and the breadth of the face in the Grimaldi woman. But these characteristics are seen in an even more pronounced form in the skull of the big man from La Grotte des Enfants, which is now in the Monaco Museum: and no one claims that this man has any negroid affinities.

It seems to me then that there are no just reasons for assuming any close affinity between the Grimaldi people and the Negro races. There is a closer kinship between them and the primitive members of the Mediterranean race, as well as the Australians. In insisting upon the resemblance of these skeletons to those of Australians I am not claiming that there is any close kinship between the earliest Europeans and the modern Australian aborigines, although the industries described by Professor Absolon in the case of the Předmost people raise this possibility for discussion. I think that the woman and child whose bodies were found at the lowest

[1] Huxley Lecture, *Journ. Roy. Anthr. Inst.*, 1924. Dr. Verneau, in fact, so interprets the meaning of the word 'negroid' as utterly to eliminate any suggestion of the Negro Race or implication of African connexions!

level in the Grotte des Enfants are undoubtedly related to the people of the Upper Palaeolithic, commonly known as the Crô-Magnon race (and in particular to the intermediate type represented by the Combe Capelle and Předmost skeletons). They are, however, much more ancient and reveal much more primitive characters, such as those that have survived in the most primitive members of the species *sapiens* at present alive, in other words the aboriginal Australians.

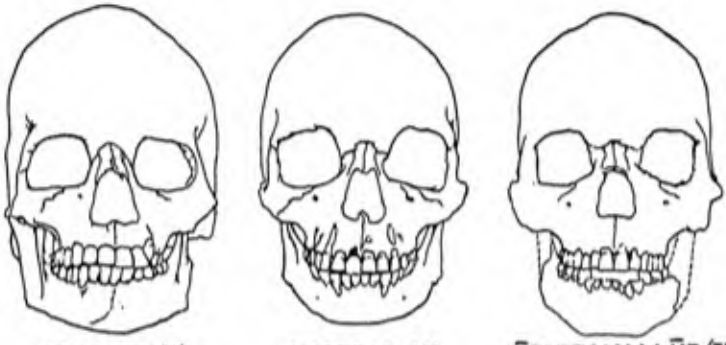

FIGURE 35. Comparison of an Australian skull and an Indian Pre-Dravidian of Australoid affinities with that of the boy from the Grotte des Enfants.

The presence of even more definite Australoid features in the early inhabitants of India is of course not a matter for surprise, because it has long been recognized that an Australoid element has survived in the jungle tribes of Southern India, as well as in Ceylon, and it is probable that this race once occupied the whole of Southern India long before people akin to the Mediterranean race of the West intruded into that Peninsula.

In this discussion I have referred to those relatively recent skulls from Adittanallūr because the undoubted Australoid skull presents features in the nose and face that recall those of the woman's skull from the Grotte des Enfants.

If these suggestions are correct, perhaps we are witnessing in the Aurignacian and Solutrean levels in Europe stages in the evolution of men closely resembling Europeans from others not unlike aboriginal Australians. This would help us more nearly to estimate the duration of the career of *Homo sapiens*. It is widely agreed that in Aurignacian times *Homo sapiens* was an immigrant into Europe. But if he came there as a very primitive and generalized type such as the Grimaldi and Předmost skeletons reveal it would suggest that perhaps he was not much older than the beginning of the Aurignacian phase of culture.

As the Australian type is quite unknown in Africa, perhaps the ancestor of *Homo sapiens*, the Australoid progenitor of the varied types of the Aurignacian levels in Europe, came from Southern Asia.

While these are mere conjectures the great variety of types found in Europe in the Aurignacian phase—types moreover that in spite of great diversity reveal tokens of kinship one with the other—itself suggests the instability of a newly evolved species.

Just as the Australian Race reveals more obvious signs of resemblance to the Neanderthal species than any other living peoples, so the Moravian and Combe Capelle crania have raised doubts as to their affinities. It has even been suggested that they are species intermediate between *Homo neanderthalensis* and *Homo sapiens* or even bastards of the former and Crô-Magnon Man! There is, however, no reason for excluding them from the species *sapiens*. Although as a whole these crania are flatter than is usual in *Homo sapiens*, none of them is nearly so flat or so Neanderthaloid as the London skull is. Yet it surely belongs to the species *sapiens*.

It can I think be most truly interpreted as another of those variants—if the most extreme—revealed by the new species when it was young and not yet crystallized into the sharply defined races that have survived into modern times.

If there is any validity in these speculations it should not be a matter of surprise if the earliest known members of the species *sapiens* (the Grimaldi, Combe Capelle, and London fossils) should reveal variations and distinctive features analogous to those displayed by the most primitive survivors of the species—the aboriginal Australians.

These considerations seem to point to the conclusion that Europe could not have been far removed from the original home of the species *sapiens*, which was probably in south-western Asia, not long before the period of the Aurignacian phase of culture in Europe.

Since this chapter has been printed the announcement has been made (*Nature*, November 20, 1926, p. 733) of the discovery at Chou Kou Tien, 25 miles from Peking, of two human teeth that are claimed to be as old as the remains of *Pithecanthropus*. But, for the reasons already explained in this chapter (p. 118), Dr. Davidson Black is not justified in claiming that these Chinese teeth 'furnish one more link in the already strong chain of evidence supporting the hypothesis of the central Asiatic origin of the Hominidae'. It cannot be too emphatically impressed upon the reader that as yet there is *no evidence* in support of the central Asiatic hypothesis. It is pure conjecture, which future discoveries may or may not confirm.

CHAPTER III

THE HUMAN BRAIN[1]

THE human brain is the instrument of the high powers of intelligence that distinguish Man from all other living creatures. The secret of Man's most distinctive attribute is hidden in the texture of his brain, and perhaps will never be fully revealed. Yet from time to time, with the growth of knowledge and the discovery of new methods of approach, we can profitably return to this greatest of all biological problems and get new glimpses of the factors that have made Man what he is. Two considerations make the present time appropriate for taking stock of the state of our knowledge of these matters. The emergence of a clearer understanding of the sequence of structural changes in the brain and body of Man's ancestors enables us to interpret some at least of the physiological factors involved in the widening and deepening of the intellectual powers and to appreciate the conditions essential for the attainment of such mental growth. In the second place, the new points of view regarding the functions of the cerebral cortex that have emerged from Dr. Henry Head's suggestive clinical investigations prompt one to examine the brain anew and endeavour to integrate the results of his brilliant analysis with those revealed in the study of the evolution of the brain. Whether or not it is yet possible fully to correlate the facts and conclusions of these two disciplines into one coherent body of doctrine, it is well worth while to make the attempt to do so, if for no other reason than to direct attention to new problems that call for solution.

[1] Discourse delivered at the Royal Institution on Friday, February 22, 1924. Reprinted from *Nature*.

In the history of organisms endowed with the power of voluntary movement, which necessarily involves the ability to choose between conflicting impulses, the fundamental condition of progress is the attainment of quickness of appropriate response. The evolution of the nervous system is the means employed to enable increasingly complex and more completely adapted muscular actions to be performed with promptitude and precision. The brain in mammals differs from that of all other living creatures, not excluding even birds, in having acquired a true neopallium, which is an instrument of almost unlimited potentialities for the cultivation of skilled movements of increasing degrees of complexity and adaptation to diverse circumstances. And in Man these potentialities achieve their highest expression. The human cerebral cortex provides the vital mechanism that can be fashioned by education to initiate and control an almost endless variety and complexity of muscular actions. It is able to perform these functions in virtue of the fullness of the information it obtains from a variety of sense-organs and the efficiency of the amazing machinery in the central nervous system for integrating the effects of these afferent currents and for controlling increasingly complex combinations of groups of muscles. But even more important still is the ability of the neopallium, by some means which is quite unknown, to record the results of past experience and to put the influence of such knowledge at the service of the muscular system. This provides the means whereby behaviour can be modified in the light of knowledge, but also enables a high degree of automatism to be acquired by training, which is perhaps the most essential factor in the attainment of high degrees of skill.[1]

The acquisition of these extensive powers plays a fundamental part in the development of the physiological dispositions that are expressed in intellectual

[1] T. H. Pear, *Skill in Work and Play* (London, 1924).

operations. In fact, in a somewhat different sense from what Professor Pear had in mind when he coined the phrase, one can support the claim for 'the intellectual respectability of muscular skill'. In the evolution of Man the attainment of increasingly skilled movement involved the growth of mind.

Before proceeding to interpret and give precision to these phrases, it will be profitable to glance for a moment at certain incidents in the past history of controversies regarding the human brain. When one considers how fundamental is the interpretation of the human brain for the understanding of the distinctive attributes of mankind, it is remarkable how little has been done to solve its important problems. By this I do not mean to suggest that the volume of the writings concerning them is small. What, however, is impressive is the fact that the vast stream of books and memoirs has brought us so few indications of any serious attempt to probe into the really vital issues regarding the way in which the brain has acquired its highest powers. It is barely a century since the knowledge of the structure and function of the brain had reached the stage that permitted really profitable discussion of its distinctive attributes in the human being. The great revolution in attitude was effected by Gall, whose services in the advancement of science are now almost completely disguised by the notoriety associated with his name as the inventor of what afterwards became known as phrenology. It was he who destroyed the ancient speculations concerning vital spirits dwelling in the ventricles of the brain. He proved that the white substance was fibrous, and introduced the method of exposing fibre-tracts by dissection to demonstrate the connexions within the nervous system. He called attention to the real significance of the grey matter. He was the first to give the correct account of the connexions of the optic tracts. The discussions arising out of his claims for cerebral localization provided the stimulus which was responsible for a profound revolution in cerebral

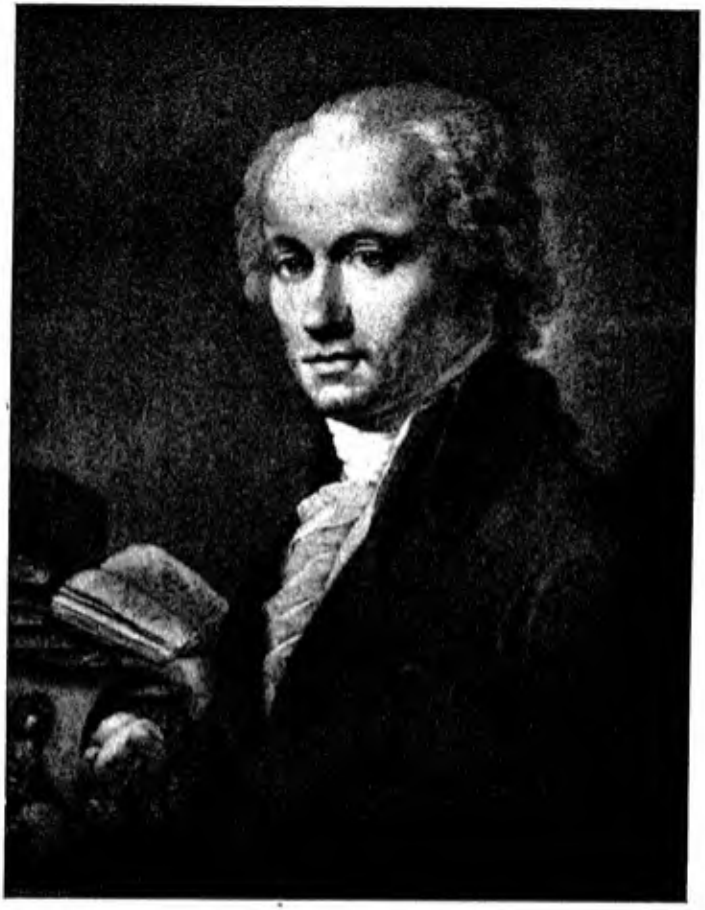

FIGURE 36
Dr. Francis Joseph Gall
(1758–1828)

physiology, even in spite of the fact that he was so incensed by the attacks of the physiologists as to deny the value of experiment. In his own lifetime it was the anatomical facts so easily susceptible of confirmation that were most violently assailed by his critics: hence the speculative and untenable part of the doctrines usually associated with his name escaped criticism and 'lived after him'. But his really great discoveries became tacitly absorbed into the great body of knowledge at the time when in later decades men were hot in pursuit of the fallacies of 'phrenology'. Although it was not until more than thirty years after Gall's death that the localization of function in the cerebral cortex began to be seriously entertained, chiefly under the influence of Hughlings Jackson and Broca, much valuable work was accomplished in the first half of the nineteenth century, most of which can be attributed directly or indirectly to the influence of Gall's teaching, as I have explained more fully elsewhere.[1]

Even before 1828 (when Gall died) attempts had been made to discover wherein the brain of Man could be differentiated from that of other mammals. Curiously enough, the remarkable claim (which Sir Richard Owen revived in 1857) was made that the human brain was distinguished by the presence of a hippocampus minor; but in 1827 Serres disposed of this assumption, as Huxley and Flower did in 1862, by showing that 'the hippocampus minor is not distinctive of Man, as hitherto has been supposed, for it is present in the Apes and Seals'.[2] It is an amazing episode in the history of this subject that Owen should have resuscitated a fallacy which had been so utterly demolished as this claim had been; but the incident was not without its uses, for it stimulated Huxley to revise the anatomy of the occipital end of the cerebral

[1] G. Elliot Smith, *The Old and the New Phrenology* (Henderson Trust Lectures, No. 1, Edinburgh, 1923).

[2] E. R. A. Serres, *Anatomie comparée du Cerveau*, Paris, 1827, t. ii, p. 583.

hemisphere and so prepared the way for the particular line of research with the latest results of which this chapter is in the main concerned. Incidentally, also, it inspired Charles Kingsley to write in *Water Babies* one of the most ironical parodies of a scientific discussion in the English language (see p. 22).

But if Serres demolished this claim for one distinctive peculiarity of Man's brain, he set up three others which have little, if any, better justification. For, he wrote, 'Man alone possesses a tonsillar lobule in his cerebellum, striae medullares in his fourth ventricle, and salient and distinct corpora mammillaria on the base of his brain'. The most arresting episodes in the history of the subject during the last hundred years have been the setting up of a series of similar false claims and their subsequent refutation. Nor, unfortunately, is this comedy of errors yet ended; although the nature of the supposed distinctions is undergoing a change.

Of the large series of supposed distinctive features of the human brain that have been extensively cited during the last half-century I shall refer here only to one directly relevant to the serious argument, which I must now set forth, based upon the further investigation of the area surrounding the sulcus which Huxley labelled 'calcarine'.

Upon the lateral aspect of the cerebral hemisphere in most of the Apes there is a furrow which was supposed to be so peculiarly distinctive of these Primates that it was labelled the *Affenspalte* or ape-fissure. More than twenty years ago its presence was demonstrated in the human brain, and as its old name was clearly inappropriate the new designation, *sulcus lunatus* (Fig. 37), in reference to the semilunar form it usually assumes, was given to it.[1]

[1] G. Elliot Smith: 'The so-called Affenspalte in the Human (Egyptian) Brain', *Anatomischer Anzeiger*, 1903; 'The Morphology of the Retrocalcarine Region of the Cortex Cerebri', *Proceedings of the Royal Society*, January 1904; 'The Morphology of the Occipital

FIGURE 37

Photograph of the back of an Egyptian brain seen obliquely from the left side, showing the *sulcus lunatus* on the left cerebral hemisphere, but not on the right.

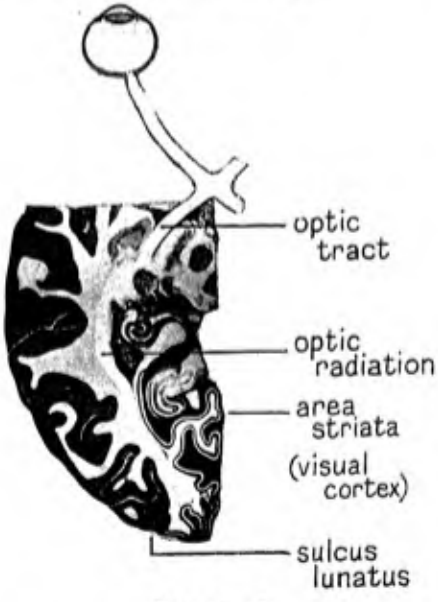

FIGURE 38

Section of human brain to indicate the course of the pathway leading from the eyes through the optic tract and optic radiation to the area striata, marked by the white line of Gennari.

The identification of this furrow was established by the study of the distribution of the cortical territory that in 1904 (*op. cit. infra*, *Proc. Roy. Soc.*) I called the *area striata* (in reference to its most obtrusive feature, the stria of Gennari), in front of which the *sulcus lunatus* is situated (Fig. 38). This led to the measurement of the extent of the area striata, in which the optic radiations end;[1] and the discovery that the visual receptive territory is just as extensive in the brains of many Monkeys, even small Macaques, as it is in those of men. In other words, in proportion to the size of the brain the area of cortex concerned with vision is relatively enormous in the lowlier Primates. This investigation led to the realization of the important part played by the early cultivation of vision as the dominant sense in Man's ancestors, and pointed to the necessity for a detailed study of how and why this particular trend in evolution should have led to results of such vast significance as the emergence of the human mind.

In Chapter I I have given a sketch of the conclusions reached in 1912 in the attempt to interpret the significance of this suggestion. Since then much has been done to probe more deeply into the nature of the processes that have been at work. These inquiries have revealed the fundamental importance of the attainment

Region of the Cerebral Hemisphere in Man and the Apes', *Anatomischer Anzeiger*, 1904; 'Studies in the Morphology of the Human Brain, with Special Reference to that of the Egyptians, No. 1, the Occipital Region', *Records of the Egyptian Government School of Medicine*, vol. ii, November 1904, pp. 125–73, 47 text-figures, 2 plates; 'New Studies on the Folding of the Visual Cortex and the Significance of the Occipital Sulci in the Human Brain', *Journal of Anatomy and Physiology*, vol. xli, pp. 198–207, January, 1907.

[1] The fact that the region to which I gave the name area striata is the receptive territory for impulses from the eyes was definitely established in 1885 by Professor S. E. Henschen of Stockholm, who has recently written an interesting account of the history of this important discovery in the *Scandinavian Scientific Review*, 1924. Thirty years earlier (1855) the Italian Panizza suggested the true localization of the Visual Centre, which Henschen proved to be correct.

of stereoscopic vision in preparing the way for the further cultivation of those high powers of discrimination and understanding that are distinctive of the Human Family.

The diagram (Fig. 2) in the Foreword was made to emphasize two important considerations: (*a*) the relative positions of the different branches of the Order Primates and (so far as it is at present possible to define them) the times at which they left the main progressive stream and became stereotyped in structure, and (*b*) the crucial phases in the evolutionary process.

Examining the condition of the brain at the first four of these significant phases, as represented (Fig. 11) in four diagrams that I prepared in 1912 to illustrate the address reprinted here as Chapter I, a great deal more information can be extracted from the facts there graphically set forth than I realized at that time. Moreover, thanks to the important researches of Drs. Le Gros Clark and Woollard much more exact information is now available than I was able to obtain. For these precise data the reader must consult their memoirs: but my old diagrams, inaccurate as they are, are not wholly without use. They demonstrate the general principle, which is given more precise and detailed expression in the drawings and photographs published by Le Gros Clark and Woollard.[1]

The Jumping Shrew has a very primitive brain with a relatively enormous olfactory apparatus, because the animal's behaviour is dominated by smell. The patchwork of cortical territories constituting the neopallium includes diminutive areas for the reception of visual, acoustic, gustatory, and tactile impressions and for the control of skilled movement.

The adoption of arboreal habits by the Jumping Shrew's cousin *Tupaia* is associated with a profound transformation in the cerebral representation of the

[1] W. E. Le Gros Clark, 'On the Brain of the Tree Shrew (*Tupaia minor*)', *Proc. Zool. Soc. London*, 1924, p. 1053; H. H. Woollard, 'The Cortical Lamination of *Tarsius*', *Journ. Anat.*, 1925, p. 86.

different senses. The olfactory area is reduced; and the whole neopallium undergoes an even more pronounced change corresponding to a relatively enormous enhancement of the importance of vision, hearing, touch, and skilled movement for an animal living in the branches of trees.

A continuation of these changes, leading more especially to a further expansion of the visual territory, is responsible for the birth of the Primates (see Fig. 2, *Prosimiae primitivae*). Also immediately one group (Tarsioidea) of the earliest Prosimiae carried this process yet another stage corresponding to the condition revealed in the living *Tarsius* (Fig. 11). The visual territory has become very extensive and the olfactory territory still further reduced in size: and this corresponds in behaviour to the definite usurpation by vision of the dominant influence formerly (even in the Lemuroidea) exercised by smell.

The reduction of the snout in *Tarsius* (Fig. 5) allows the eyes to come to the front of the face and to look forward. It also permits the visual fields of the two eyes to overlap, and so prepares the way for the acquisition of stereoscopic vision. But although *Tarsius* has binocular vision, it is not capable of appreciating stereoscopic effects. Probably it lacks the ability to appreciate the exact form and solidity of objects and to discriminate between substance and shadow. Nor is it yet able to appreciate the texture or the details of the things seen. For this purpose it is necessary to be able to move the two eyes in any direction in the closest co-ordination the one with the other; and *Tarsius* has not yet developed the complicated machinery necessary for effecting these nicely balanced adjustments. That it feels the need of these powers is evident. For *Tarsius* has acquired the power of moving its head upon the vertebral column throughout an extraordinarily wide range. In fact, with its body pressed against a tree-branch (Fig. 39) it can turn its head almost to the extent of 180° and

look backward. This means that *Tarsius* feels the need for moving its two eyes in co-operation the one with the other, but as it lacks the necessary range and precision of conjugate movements, it moves its head much as a cat does, and so roughly achieves its purpose of bringing the two eyes at the same distance from the object.

The enormous expansion of the cerebral cortex in the transition from the Tarsioid to the true Monkey is shown by contrasting the brains of *Tarsius* and *Hapale*. There is a sudden increase not only in the visual territory but in almost every other neopallial area, tactile, motor, acoustic, and prefrontal. The latter is peculiarly significant. For experimental researches, especially those of Mott and Sharpey Schafer, Risien Russell, and Sherrington and Leyton, have demonstrated (see Figs. 12 and 13) that the prefrontal area (the cultivation of which is related to the process of learning to perform skilled movements) is more especially associated with the acquisition of a wide range of conjugate movements of the eyes and of the power of exact convergence, which is necessary for the fixation of the eyes upon any object so that its image can be focused with precision upon associated spots in the two retinae. The ability to do this (in a mammal with conjugately linked eye-movements) is essential before a macula lutea or sensitive spot can develop, in virtue of which the appreciation of texture, detail, and colour becomes suddenly enhanced. But other profound structural changes are necessary before stereoscopic vision is acquired. Not only must the cortical instrument (prefrontal area) voluntarily perform the skilled movements that are necessary, and a specially sensitive spot (macula lutea) in the retina be evolved, but also the optic tracts must be rearranged so that the nerve-fibres from the parts of the retina in physiological correlation one with the other proceed to the same parts of the brain. Moreover, the oculomotor nucleus in the mid-brain is

FIGURE 39

Tarsius (with her baby) showing the head looking directly backward, turned at almost 180 degrees with the axis of the body.

(*From a photograph lent by Mr. W. E. Le Gros Clark, F.R.C.S.*)

remodelled so that it can effect automatically the conjugate movements of the eyes which the prefrontal cortex can consciously control. The ability to carry out these complex adjustments unconsciously enables the individual to concentrate his attention upon the thing seen rather than merely upon the muscular act necessary for seeing it.

Woollard's recent researches[1] have demonstrated that although *Tarsius* has not acquired a fully developed macula lutea and fovea (a depression due to the clearing away from the path of the light rays in the sensitive spot of the retina the obstruction of the nerve-fibres and cells) changes are developing in the structure of the retina in an area corresponding to that in which the true macula and fovea are found in Monkeys.

The investigations of Brouwer, supplemented by Hunter's comparative examination of the oculomotor nuclei of *Tarsius* and the lemuroid *Nycticebus*, have elucidated these interesting facts, which provide so clear a corroboration of the inferences drawn from a study of the cerebral cortex.[2] One of the most significant of the changes that occur in the transition from the prosimian to the simian stage—in other words, that mark the acquisition of stereoscopic vision—is the splitting up of the nucleus for accommodation. This seems to create the possibility that each eye can be focused independently upon any object. The value and significance of such an arrangement might be that the two sharply defined and exactly focused images can be obtained even if the object is seen obliquely, and is therefore farther away from one eye than the other. In other words, the animal is not compelled to move its head, as *Tarsius* does, so as to bring the two eyes into a position equidistant from the object. The

[1] H. H. Woollard, 'The Anatomy of *Tarsius spectrum*', *Proc. Zool. Soc. London*, 1925, p. 1109; 'Notes on the Retina and Lateral Geniculate Body in *Tupaia*, *Tarsius*, *Nycticebus* and *Hapale*', *Brain*, 1926, p. 77.

[2] John I. Hunter, 'The Oculomotor Nucleus in *Tarsius* and *Nycticebus*', *Brain*, 1923.

eyes alone may be moved. It would be difficult to exaggerate the vast importance of this change in enabling the higher Primate to appreciate the form and size of objects by following their outline by means of delicate eye-movements. The possibility of accommodating one eye to a different degree to the other is denied by some authorities. But the anatomical facts brought to light by Dr. Brouwer seem to suggest an increased independence of the two eyes in respect of this function in the Apes and Man.

Man has evolved as the result of the continuous exploitation throughout the Tertiary Period of the vast possibilities which the reliance upon vision as the guiding sense created for a mammal that had not lost the plasticity of its hands by too early specialization. Under the guidance of vision the hands were able to acquire skill in action and incidentally to become the instruments of an increasingly sensitive tactile discrimination, which again reacted upon the motor mechanisms and made possible the attainment of yet higher degrees of muscular skill. But this in turn reacted upon the control of ocular movements and prepared the way for the acquisition of stereoscopic vision and a fuller understanding of the world and the nature of the things and activities in it. For the cultivation of manual dexterity was effected by means of the development of certain cortical mechanisms; and the facility in the performance of skilled movements once acquired was not a monopoly of the hands but was at the service of all muscles. Skilful use of the hands was impossible without the appropriate posturing of the whole body. High co-ordination of hand movements and high co-ordination of movements of the muscles of the whole body must go together. The sudden extension of the range of conjugate movements of the eyes and the attainment of more precise and effective convergence were results that accrued from this fuller cultivation of muscular skill. They were brought about as the result of the expansion

of the prefrontal cortex, which provided the controlling instrument, and also by the building up in the mid-brain of the mechanism for automatically regulating the complex co-ordinations necessary to move the two eyes in association in any direction. The attainment of stereoscopic vision enormously enhanced the value of the information acquired by the eyes.

These claims seem to involve the assumption that the transmission of acquired characters may have occurred in the process of transformation of a Tarsioid into a Monkey. This vast problem cannot be discussed here: but its implications cannot be evaded. It must be recognized that the originally independent movements of the eyes, which could by a difficult voluntary effort be co-ordinated, gave place to automatic linked (conjugate) movements of the two eyes, the range and precision of which became extended as the power of learning to attain skill in other movements increased. The exact determination of the sequence of developments whereby a highly complex series of voluntary co-ordinated movements came to be acquired and rendered automatic seems to imply that in some way the increasing ability to perform such actions by an intense effort of the will was transmitted hereditarily.

The development of maculae luteae made possible the fuller appreciation of the details, the texture, and the colour of objects seen, and in association with the increased precision of muscular control enabled the eyes to follow the outlines of objects and appreciate better their exact size, shape, and position in space. But this completer vision of objects in the outside world stimulated a curiosity to examine and handle them, and so led to still further cultivation of skill in movement and an enhancement of tactile discrimination. This higher skill was attainable because the powers of stereoscopic vision conferred more accurate control upon the hands than was possible before it was at their service.

Thus the fuller cultivation of the results of the

visual powers provides a new stimulus and new means for enhancing vision itself, and this cycle of developmental changes was repeated again and again in the history of the Primates, at each stage leading to a further enhancement of muscular skill and visual acuity.

It is of fundamental importance to remember that one result of the continued handling of objects is the attainment of a fuller understanding of their properties and of the natural laws involved in their movements. The closer correlation of the information gained by vision and touch played a leading part in the cultivation of an appreciation of form, which represents the germ of the aesthetic sense. There also emerged the aptitudes to estimate weight and to discriminate between textures, functions that seem to be dependent on the integrity of the parietal cortex.

When these had attained such a degree of exactitude that it became possible for the individual to distinguish sharply one object from another and to appreciate its manifold properties, the time had arrived when the process of naming it acquired a definite biological value. In other words, once it became possible to recognize a particular object it became useful to invent a label for it. Man's ancestors were already provided with the muscular instruments for speech and the ability to use them for the emission of a variety of signals, mainly in the nature of cries to express emotional states. Hence, long before the need made itself felt for an instrument to express the names of objects, it was already in being, and all that required to be done was to devise the necessary vocal symbolism to express the visual experience—to give a name to an object seen. Moreover, long before the acquisition of articulate speech, the ancestors of modern Man were conveying information of an intellectual kind one to another through the visual appreciation of the meaning of gestures and facial expressions. With the introduction of an auditory symbolism Man continued to do

what he had done previously in a manner less precise and less capable of intellectual elaboration.

The ability to recognize the details of objects seen and the attainment of a more delicate and exact discrimination of form, colour, and movement conferred upon Man's immediate ancestors some of the distinctive attributes that in the course of time transformed them into men. In virtue of these new powers a fuller understanding was acquired of the gestures and facial expressions of Man's fellows, and their significance and appreciation of the aesthetic qualities of their form, colour, and movements.

Man studies the actions and facial movements of his fellows and from them learns to interpret their sentiments and intentions—in particular their attitude towards himself. Not only does he acquire such information by means of his own eyes, but in addition the eyes of his fellows themselves afford the most illuminating signals of their owner's thoughts once he has learned to detect the subtle changes that occur in them. Just as the fixing of his own gaze implies the concentration of his attention upon some definite object, so he—as it were instinctively—interprets the immediate interests of his fellow men and women by appreciating the object or point in space towards which the visual axes of the individual he is watching are directed. When he 'looks another man in the face' this involves a mutual inquiry and a frank communication of feeling and knowledge one to the other. Such ocular signalling is the most eloquent form of intercommunication between the sexes—as the slang expressions in every language reveal. Vision is obviously of vast significance as an instrument of sexual selection in mankind. The appreciation of beauty of form and colour, as well as of the charm of posture and movement, is rendered possible by Man's distinctive powers of vision. But vision has not only become the dominant influence in sexual choice, but its potency has become so enhanced in Man as to override all those conditions that in other

living creatures restrict pairing to certain seasons when the sexual glands reveal their distinctive activities and scent glands excite the sexual appetite and almost automatically impel a pair to mate. But when vision acquired its domination over behaviour the factors that determine sexual discrimination and attraction were brought more definitely under the influence of the cerebral cortex (the neopallium). With the superseding of smell by vision the special scent glands that play so large a part in sexual excitation in some animals disappeared, and in certain Monkeys Nature replaced them by brilliant colours as a sexual allurement. But in the highest Primates these grosser forms of visual attraction were sublimated, and aesthetic appreciation became the obtrusive factor in the conscious choice of mates, and sexual intercourse was no longer restricted to definite seasons. When due recognition is given to the unquestionable fact that sexual selection in mankind is essentially determined by visual discrimination, the further problem arises as to what extent the profound transformations of Man's bodily form—the shape and proportions of the limbs, the erect attitude, the loss of hair on trunk and limbs, the modelling of the female form by localized developments of fact—are affected by such selection.

The factors concerned in these changes—the transmutation of the bestial characters of an Ape into the graceful form of a human being—involve complex readjustments of the functions of the nervous and endocrine systems. Only one of these I need refer to now.

Skill and Posture.

Man's outstanding distinction depends on the range of his intelligence, his ability to learn from his individual experience, and to acquire knowledge and discrimination so as to modify his behaviour in the light of his former trials and errors. Such powers depend not only on the ability to see and observe but also to act and to

learn from experimentation. The attainment of muscular skill is an essential condition of human existence, and every child is impelled by a dominating instinct to acquire such skill. From the time of its birth an irresistible impulse compels it to practise the use of its hands and to acquire the conjugate movements of its eyes. Nor can it resist the compelling force that drives it to practise daily and hourly until it can stand on its feet and walk in the erect attitude. A similar instinct forces it to cultivate the complex series of skilled movements that are essential for the acquisition of articulate speech. So deep is this striving to acquire muscular skill ingrained in human nature that the child, once it has satisfied the innate impulse to walk and talk, indulges the craving still further in games which in some form or other continue to appeal to its interest throughout life.

The consideration of this outstanding attribute of mankind involves the discussion of the factors involved in acquiring skill, regulating posture and the erect attitude, the differentiation of the limbs into organs of locomotion and hands as the instruments of skill and the special organs of tactile discrimination, the development of right-handedness, and the acquisition of speech.

Each of these topics would need an extensive volume to provide an appreciation even of our present imperfect knowledge of them. Hence I can do no more than refer briefly to certain aspects of these large problems.

About a century ago, it was a popular occupation among anatomists and physiologists to write treatises upon the beautiful mechanism of the human hand, and assume that the hand had been so specialized as to become the most superb illustration of design in nature. The human hand, as a matter of fact, is an extremely primitive mechanism. It retains the same structure as the hand of the earliest mammals, and reveals a great many features that are found in the most primitive reptiles and amphibians. The earliest vertebrates to adopt a terrestrial mode of life developed limbs for the

new method of locomotion on land. The distinctive feature of the hand is that it retains the primitive characters (such as the five fingers) of these original Tetrapoda. When the brain had developed in such a way as to acquire greatly heightened powers of initiating and directing skilled movements of increasing degrees of complexity and refinement, it was able to use this unspecialized member for an endless variety of new purposes. This manual instrument, being still free from specialization, was plastic, and could be adapted to almost any purpose the brain directed. The human limbs that have become specialized are the legs. The legs are highly modified in adaptation to a new mode of progression that is distinctive of Man. It was the transformation of the feet that played a large part in liberating the hands from the work of locomotion.

The lengthening of the legs and the transformation of the feet are intimately correlated with certain changes in the brain that made possible the new posture and mode of locomotion for which the legs are adapted. I do not propose to discuss the progressive changes that were gradually effected in the legs and feet to make them adequate to maintain the body in the erect attitude. The admirable series of memoirs by Dr. Dudley J. Morton has demonstrated how conclusive a proof the structure of the foot affords of Man's kinship to the Gorilla and of the fact that the series of changes that have been so gradually transforming the foot in the Primates was not completed when the Human Family emerged, but was continued in its extinct members until the type of foot distinctive of *Homo sapiens* emerged.[1]

In the evolution of four-footed animals an automatic mechanism of amazing efficiency has been built up in the central nervous system for the automatic regulation of posture. For the elucidation of this aspect of the working of the nervous and muscular system we are chiefly indebted to the brilliant pioneer work of Sir Charles

[1] 'Significant Characteristics of the Neanderthal Foot', *Natural History*, 1926, p. 310.

Sherrington and the later work of Professor Magnus of Utrecht. An animal like a Cat when deprived of its cerebral hemispheres can still assume a normal posture. Not only so, it can be adapted to changes in the conditions and quite unconsciously and automatically. Impulses passing to the central nervous system from the labyrinth of the internal ear, from the muscles and joints and in particular the muscles of the neck, can reflexly control the tone of the muscles of the body as a whole so that the animal, deprived of its cerebrum, can maintain a standing posture. The posture of an animal is thus due to muscle-tone—a reflex effect upon a muscle maintaining it at a certain length—so that the act of standing in a four-footed animal is automatic or reflex, that is, does not need an act of the will to bring it about. But it must be obvious that if the instrument of the will—the neopallium—consciously provokes some voluntary purposive movement, it has so to speak to unlock the fixed attitude of the automatic reflex posture before its stimulus can take effect. Moreover, all voluntary movements, however simple they may seem, are accompanied by appropriate postural adjustments of the muscles of the body as a whole. So that in effecting any purposive action the cerebral cortex in some way has both to release the tone and readjust the posture of the body. Any one watching a child learning to write, or to perform any action calling for muscular skill, will realize how the posture of every part of the body, tongue, lips, face, legs, &c., is being played upon. These contortions are not being performed intentionally or even consciously. The primary action is being performed under direct control, but all the manifold postural adaptations are taking place reflexly—all these strange associated movements are involuntary.

In Man, however, these automatic postural reactions are brought under more direct control of the will ; and the more complete co-operation between muscular activities that are wittingly performed and the postural

adaptations to permit them to be performed with precision and quickness represent the conditions for the attainment of skill. The neopallium acquires an increasing influence over posture and voluntary muscular activity as the control of vision becomes enhanced.

Even in the most primitive animals the eyes, which were evolved originally to appreciate movement (and of course luminosity), play a part in the regulation of posture. But in the quadrupedal animals the labyrinth and the afferent nerves from muscles and joints acquire an almost exclusive and automatically regulating control. In the higher mammals vision begins to reassert its influence upon posture.

In his Croonian Lecture[1] to the Royal Society in 1925 Professor Magnus called attention to the fact that in Monkeys (and certain other mammals in which vision plays an important part in guiding movements) the eyes begin to assume function of regulating posture and muscle-tone—what Magnus calls the optical righting reflexes develop. This involved the action of the cerebral cortex, whereas the more primitive nervous mechanisms for controlling posture are sub-cortical, in other words are placed in the brain-stem. The increasing influence of vision as the guiding sense added to the significance of the cortex as a posture-regulating instrument. This was an important factor in the development of the erect attitude in Man, which is maintained by conscious activity and is not an automatic posture to the same extent as that of four-footed animals is. The erect attitude was not the cause, as so many writers have assumed, of Man's intellectual pre-eminence. If it liberated the hands from the function of locomotion and so enabled them to attain higher possibilities of skilled action and tactile discrimination, it must not be forgotten that the erect attitude itself was made possible by the higher development of the brain, which not only conferred these aptitudes on the hands, but also created new conditions for the regulation of

[1] 'Animal Posture', *Proc. Roy. Soc.*, Series B, vol. 98, 1925, p. 339.

posture and a closer correlation between the functions of releasing muscle-tone and initiating a skilled movement.

Thus the liberation of the hands and the progressive development of the cerebral cortex were parts of one and the same process, of which the latter was the essential element. But the hands are the instruments whereby the cerebral cortex expresses its distinctive powers. Manual dexterity involves experimentation and the process of learning the properties of things and of the forces in the world.

I have already emphasized the consideration that with the origin of mammals the transference to the neopallium of the direct control of movements, which previously had been regulated by the mid-brain, represented merely the beginning of the process of building up in the cerebral cortex of a closely co-ordinated mechanism for the attainment of skill. The acquisition of an increased influence over posture regulation conferred upon the neopallium the possibility of the development of much higher degrees of skill, and in particular those forms of it that in Man are so intimately bound up with the erect attitude. For in the majority of Man's activities skilful balancing of the body and rapid adaptations of posture are integral parts of the perfect movement. In cricket, tennis, and golf, and in fact every skilful action, the perfection of stroke is not achieved simply by movements of the hands, but also by the rhythm of the whole body—the 'swing' and the 'footwork', as the sporting journalist expresses it. But these possibilities have been attained only by the most profound changes in the brain. The great prefrontal and inferior temporal expansions of the neopallium in the Anthropoid Apes and Man (Fig. 40—compare Figs. 11, 12, and 13) are intimately associated with the ability to display muscular skill.

From the prefrontal area a great strand of nerve fibres passes downward to establish connexions with the automatic tone-regulating mechanisms in the lower

parts of the brain. When this area or the fibre-tract arising from it is thrown out of action the restraint is removed from the complicated muscular mechanisms that automatically maintain the posture of the body: hence the limbs tend to become rigid in a position of extension. Alternatively under normal conditions when the prefrontal area comes into action it releases the fixed posture so that the muscles can obey the impulses determining skilled action. These functions have been clearly elucidated by the experiments of Drs. Warner and Olmsted of Toronto, which were published in *Brain* (1923, p. 189). Drs. Bernis and Spiegel, working in Professor Marburg's laboratory in Vienna, have recently (*Arbeiten aus dem Neurologischen Institut an der Wiener Universität*, 1925, p. 197) called attention to an analogous function performed by the temporal area of the cerebral cortex. They have shown that this part of the neopallium has a slight influence upon the tone of muscles in cats and four-footed animals, which becomes tremendously enhanced in Man. It regulates the tonic reflex actions of the labyrinth (the part of the internal ear involved in postural functions) and acts in collaboration with the cerebellum in much the same way as the prefrontal cortex was shown to do in Drs. Warner and Olmsted's experiments.

It is possible that this close correlation between the labyrinth of the internal ear and the temporal cortex on the one hand and the muscular system on the other may represent the factors determining the vast significance of rhythm in human activities, not merely in the performance of many consciously skilled movements, but in particular in Man's ordinary locomotion and such special variations of it as running and dancing. The rhythms of music and of movement are perhaps brought into harmony by the activities of the temporal cortex, which is both the receptive area for acoustic stimuli and the executive area for regulating the rhythms of posture.

The reality of the influence of the prefrontal and

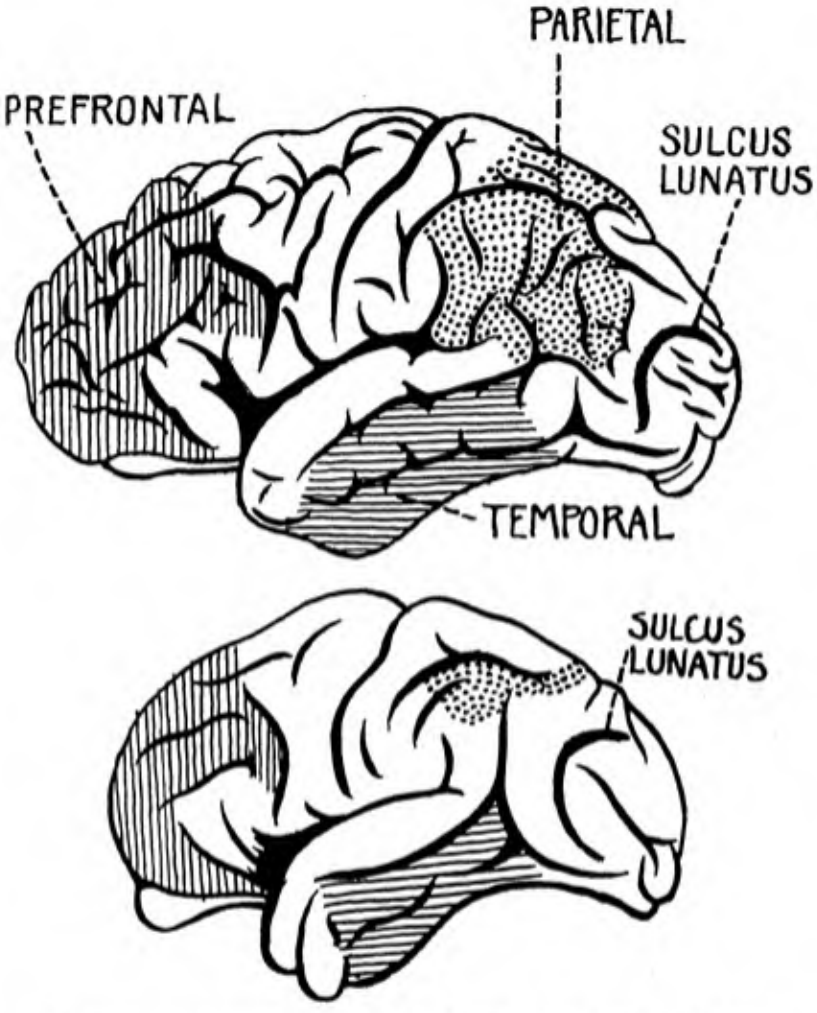

FIGURE 40. A comparison of the left hemisphere of a Gorilla's brain (below) with that of the most Ape-like human brain ever recorded to indicate the three areas (parietal, temporal, and prefrontal) that undergo the chief expansion in the evolution of Man.

In most human brains these shaded areas are enormously bigger than they are in this exceptionally primitive specimen.

temporal cortex on cerebellar and muscular functions is confirmed by the anatomical fact of the vast strands of nerve fibres connecting these two neopallial areas with the cerebellum. The claim for a similar connexion between the parietal area and the cerebellum is not so well established. But on *a priori* grounds one might expect an area so intimately associated with the appreciation of movement and with the afferent impulses from skin, joints, and muscles to play an important part in such functions.

When the complicated nature of the association involved in muscular action is considered, the harmonizing of the purely willed with the automatic into one purposive and smoothly working process, the possibility suggests itself that one of the factors involved in training and the acquisition of skill must be the integration of these two types of activity. The voluntary part of the process is repeated again and again until it becomes an acquired automatism, by which in this case is meant a rhythm in accord with that of the associated postural changes in the body as a whole. When this perfection of automatic harmony is attained the will is free to use it as a smoothly running mechanism and adapt it voluntary to changing circumstances—such as the visual impression of the flight of a ball in a game like tennis and cricket. But it is well known that fixing the attention upon the more automatic part (i. e. the acquired automatism) of the process is a hindrance to successful achievement. The old fable of the centipede who was thrown into confusion by thinking about which foot should move next illustrates the point. The success of a skilled action depends upon the fact that the major portion of the bodily action should be automatic so as to permit the attention to be concentrated on the changing details, such as the flight of a ball and the best means of using the acquired automatisms to deal with a specific problem. Without the correct posturing and rhythm of movement no amount of skill in the conscious part of an action can avail anything.

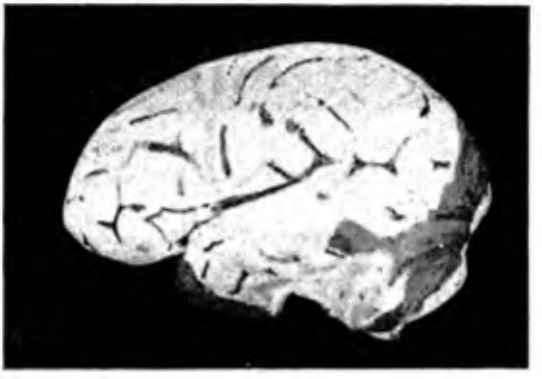

FIGURE 41

Restoration of the Brain of Piltdown Man—
lateral aspect of the left hemisphere

All these considerations afford a very impressive demonstration of the importance of muscular skill in human activity. The fact that the chief instrument of Man's intelligence should be so largely concerned in the control of muscular activities affords very emphatic proof of the fact that the human mind is the product of skill in action. Man's understanding of the world and the events happening in it is based upon the ability not merely to see but to act. It is the manipulative skill that confers upon mankind the high powers of intelligence that are their distinctive attribute.

In the light of these observations the progressive expansion of the prefrontal and temporal areas of the neopallium in the Primates acquires a fuller significance. It affords a rough measure of the attainment of skill and understanding. But the process did not come to a stop when mankind made their appearance. The process of growth (and no doubt also increase of efficiency) continued within the Human Family right up to *Homo sapiens*, who to judge from the erectness of his posture and the delicacy of his hands is immeasurably more skilful than any of his predecessors, such as the slouching, coarse-handed, Neanderthal Man.

Attention has already been called to the increase of the three significant cortical areas in the Human Family. Even when the exceptionally large brain of a Gorilla is compared with the most primitive human brain available for study (Fig. 40) the increase of these territories is clearly the fundamental difference between Ape and Man. The human brain shown in Fig. 40 is, however, phenomenally primitive. In size, shape, and in the arrangement of its sulci it presents a very remarkable likeness to the restoration of the brain of Piltdown Man that I made in 1913 (Fig. 41).

If this old photograph be compared with the diagram of the endocranial cast obtained from the Rhodesian skull (Fig. 42) certain interesting facts emerge. In both brains there are indications suggesting an open condition of the Sylvian fissure (*S*)—an

approximation to the simian condition, that is also expressive of the poor development of the frontal (*F*) and temporary areas (*T*). The localized development of the posterior temporal area to form a distinct boss (the dotted ellipse surrounding *T*) is found equally in *Pithecanthropus*, *Eoanthropus*, the Rhodesian cast (Fig. 42), certain of Neanderthal series (especially the original La Quina specimen), and the cast of the London skull (Fig. 46).

The defective development of the prefrontal (*F*) and parietal (*P* and *D*) areas that is so obtrusive in the Rhodesian cast is even more pronounced in *Eoanthropus*, and still more so in *Pithecanthropus*. But in the Rhodesian cast there are signs of the spreading upwards into the parietal territory (*P*) of the fullness of the posterior temporal area (*T*), a tendency that becomes more pronounced in the Neanderthal series of endocranial casts. In all these extinct members of the Human Family the temporal area (excepting the boss at *T*) is poorly developed.

In the light of the foregoing discussion of the neopallial control of muscle-tone and its relation to the development of skill and the erect posture the deficiencies of these significant areas and their progressive expansion in the Human Family are interesting because they seem to give tangible expression to the theoretical inferences as to the gradual attainment of skill.

In all these casts there is a noteworthy fullness of the area (*O*) in front of the Sylvian deficiency (*S*). This prominence is due not merely to contrast with the defective prefrontal area (*F*) above it, but also to an actual increase in size of an area corresponding to that distinguished by the number 27 in Flechsing's diagram (Fig. 29) of the human child's brain. This localized expansion is of particular interest because it confers upon all human brains, not excluding even those of *Pithecanthropus* and *Eoanthropus*, a definite orbital margin (below the letter *O*) separating the under (orbital) surface from the lateral. The prominence of

the area marked *O* is not so great either in the Piltdown or the Javan casts; but in each case there is a definite orbital margin.

This peculiarity of the human brain is of special interest in reference to the state of affairs revealed in the natural cast of the Taungs Ape. For there is just sufficient of the cast preserved (Fig. 43, B) to show that the orbital margin was developed in *Australopithecus* in a form as pronounced as that of *Pithec-*

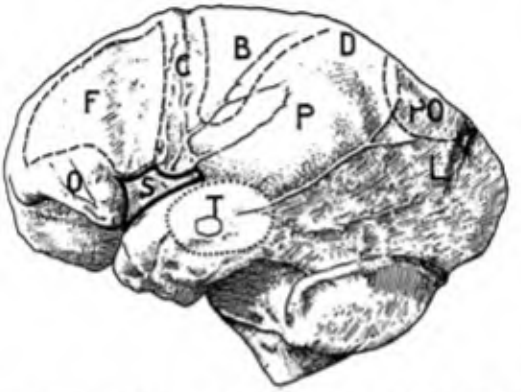

FIGURE 42. Diagram of the endocranial cast of the Rhodesian skull seen from the left side. *circa* $\frac{4}{10}$.

anthropus (*C*), and in marked contrast to the gently rounded margin of the brain in the Gorilla (*A*).

The development of the orbital margin in *Australopithecus* is one of the expressions of a definite increase in size of the prefrontal area (*B*) in comparison with that of the Gorilla (*A*). This affords very valuable and objective corroboration for Professor Dart's claim (which was based primarily on the contrast in the parietal proportions) that the Taungs Ape reveals evidence of a definite if slight advance towards the human condition.

Although the skull is that of a simian infant, in which the first permanent tooth had only just erupted, the capacity of the Taungs brain-case was more than

500 c.cm., about 200 c.cm. larger than the average size of the brain in Chimpanzees of the same age. By measuring the volume of the cranial cavity of nearly a hundred Chimpanzees Mr. S. Zuckerman has been able to prove that, contrary to the common opinion, the brain continues to grow after the time of the eruption of the first molar tooth. According to these figures at least 10 per cent. (and on the analogy of some Chimpanzees proportions varying up to as much as 40 per cent.) might have to be added to the 500 c.cm. to arrive at the correct capacity of the brain-case in the adult *Australopithecus*, which may have been as large as (if not considerably larger than) that of the most capacious Gorilla's cranium. The fact that the brain of the Taungs Ape was far from being fully grown is also revealed by the very small size of the cerebellum—an infantile trait. Even if no other change than the growth of the cerebellum were effected in the size of the brain by its attainment of the adult state it would become at least as big as the largest simian brain. The probability is that it would have attained a larger size.

The Significance of Man's Neopallium.

Now that the tentative hypothesis to express the known biological facts has been formulated it is profitable to consider what light is thrown upon the issues by Dr. Head's clinical investigations, more especially by his memoirs 'Sensation and the Cerebral Cortex' (*Brain*, 1918), 'Speech and the Cerebral Localization' (*Brain*, 1923), and *Aphasia and Kindred Disorders of Speech* (1926).

In these works Dr. Head defines the functions of those parts of the cortex concerned with sensation. Injury to any part of the cortex disturbs attention. The cortex is the repository of past impressions, and these sensory dispositions profoundly modify the effect produced by the arrival of fresh impulses. But the sensory cortex is concerned also with the power of appreciating the differences in weight, shape, relative

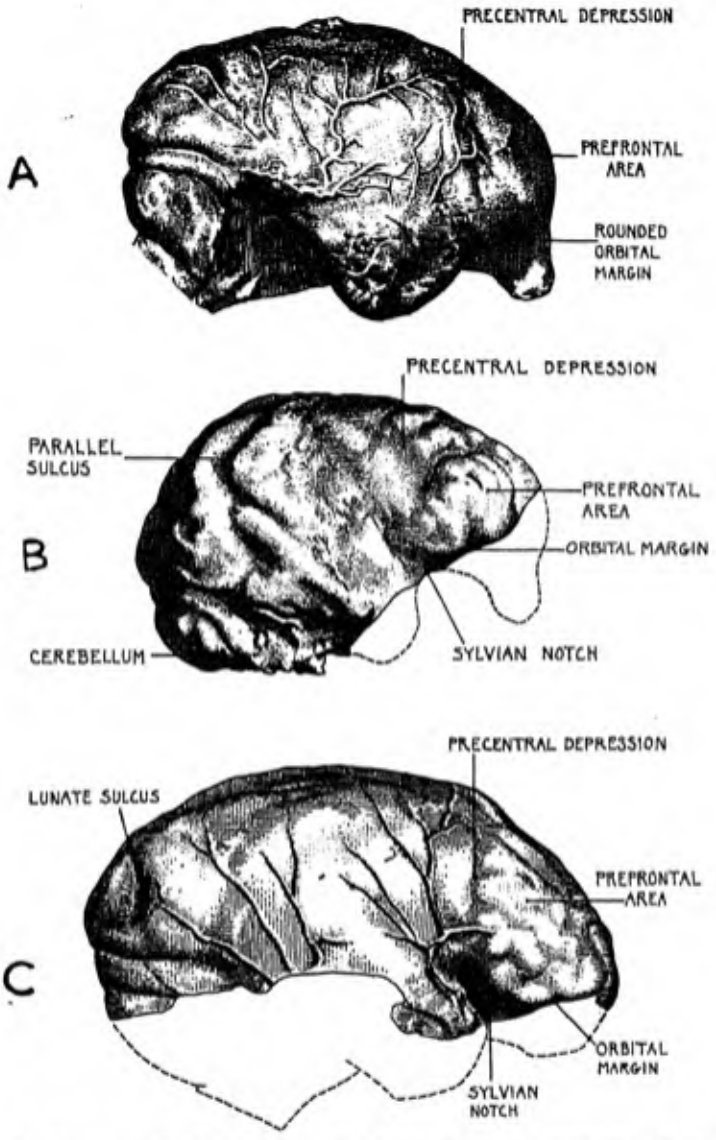

FIGURE 43. Drawings of the right aspects of endocranial casts of an adult Gorilla (A), the Taungs Ape (B), and *Pithecanthropus* by T. L. Poulton (C) × $\frac{7}{12}$.

The right side is shown (and not the left as in the other diagrams) because the left side of the Taungs specimen is missing.

size, and texture of objects, and is also responsible for the spatial aspects of sensation.

The facts relating to the evolution of the cerebral cortex in the Primates suggest the explanation of how these abilities, which in their fully developed form are so distinctive of Man, have been acquired, by the progressive cultivation and co-operation of vision and touch with the acquisition of skill in movement. The parietal area (Fig. 40) is the chief instrument whereby this intimate correlation of visual and tactile experience is acquired. The hand becomes the sense organ for this enormously enhanced aptitude for tactile discrimination, whereby the nature of things is so largely estimated and their meaning and identity established. The area concerned with these functions derives its power of spatial reference mainly from its connexion with the visual cortex (the unshaded territory behind the stippled parietal area in Fig. 13). With reference to the latter Dr. Rivers has given a clear account of the facts. The physiological basis of localization in space is the simultaneous stimulation of both retinae. The perception of form and size depends not merely on the retinal images but also on minute movements of the eyes following the outlines of the object. The acquisition of the ability to extract such information from visual experience obviously depends upon the power to effect the complex conjugate movements of the eyes with the necessary precision. It has already been seen that such extensive and exact powers of conjugate movement were first acquired in the evolution of Monkeys from a Tarsioid, and undergo a progressive development that culminates in Man.

Perception of form in three dimensions—solidity—depends primarily on the physiological binocular mechanism for relative distance, but is profoundly influenced also by such psychological factors as light and shade and the ability to discriminate between substance and shadow—one of the results of stereoscopic vision.[1]

[1] W. H. R. Rivers, Schäfer's *Text-book of Physiology*, vol. ii, p. 1132.

Head has emphasized the fact that sensory experience can only form part of a consecutive consciousness by virtue of the coherence which otherwise isolated incidents receive from the projected aspects[1] of sensation. The activity of the cerebral cortex is essential for giving us our conceptions of coherence both in space and in time (see remarks on mental coherence, p. 52).

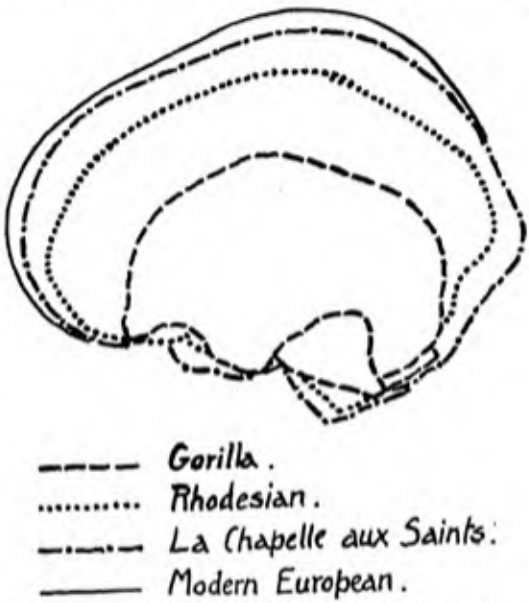

FIGURE 44. A series of profiles superimposed to indicate the relative proportions of the brain in the Gorilla, Rhodesian Man, Neanderthal Man, and Modern Man.

Without the ability to refer the results of our sensations to the outside world—to some definite locality in space—the material stimulus would fail to convey any ideas of size, shape, weight, texture, and intensity.

The appreciation of beauty of form and colour, as

[1] By projected aspects is meant the state of consciousness excited by stimulating a sense organ, such as the eye, whereby the individual refers the sensation not to the part of his body affected by the stimulus, but to some place outside his body or to something perhaps far distant in space.

well as of sound and rhythm, was acquired as one of the results of the cultivation of the powers of discrimination, the evolution of which I have been trying to interpret as an outcome of the development of the abilities conferred by stereoscopic vision. The further investigation of these evolutionary processes will, I believe, afford the interpretation of the biological foundation of aesthetics.

Appreciation of the nature of the objects and events happening in the outside world are dependent upon certain cortical developments which did not occur until Man's immediate ancestors were assuming human qualities. The attainment of the realization of space and time, and a tremendous increase of range and precision in recognizing objects by their shape, colour, size, and texture, marked the transformation of the Ape into a Man. For the ability to appreciate the manifold qualities and distinctive differences made it biologically useful for him to devise names for things, and so initiated the development and use of language with all that language implies in vastly increased capacity for thinking in symbols of value to himself and intelligible to others.

Thus the origin of speech can be brought into logical connexion with the other factors that are expressed in the expansion of the parietal, prefrontal, and temporal cortex.

In the primitive human brain, such as the endocranial cast of *Pithecanthropus* enables us to picture, there is a very pronounced local growth of the posterior part of the second temporal convolution, to which attention has already been called. This sudden expansion in the earliest-known member of the Human Family of the territory adjoining the receptive area for impulses from the organ of hearing, implies a great enhancement of the biological significance of acoustic symbolism. This can have only one meaning. The most primitive member of the Family had already acquired some sort of speech—a fuller ability to understand the vocal

symbols enunciated by his fellows. The acquisition of speech was, in fact, an essential part of the process of transforming an Ape into a human being.

Primitive speech, apart from mere emotional cries such as animals endowed with a true sense of hearing emit, no doubt began with imperative verbs differing only in their variety and fuller meaning from instinctive cries. But when names were invented, at first by the definition of a visual experience for which

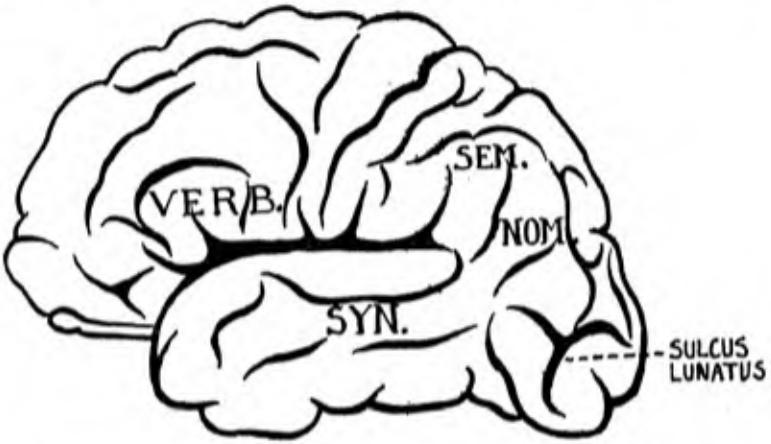

FIGURE 45. Diagram to illustrate the areas injury to which affects speech in different ways: (nominally (NOM.), verbally (VERB.), syntactically (SYN.), and semantically (SEM.).

a verbal symbol was devised, it became possible for men to communicate the one with the other in sentences of two words after the manner of Alfred Jingle in *Pickwick Papers*.

But it required a much more elaborate cultivation of the acoustic territories of the cortex (Fig. 45, SYN.) before real sentences were devised by the syntactic process of linking together a series of words to express a meaning which was not simply that of the individual words or the combination of them, but, so to speak, a glorified word with an individuality and a meaning of its own and a rhythm of enunciation some-

what akin to music. As a complement to this power of controlled expression of highly complex acoustic symbols, which is made possible by physiological dispositions in the temporal area (SYN.), there is added a wider understanding of the significance of the symbolism so elaborated, which apparently is made possible by the development of the parietal area (supramarginal convolution, Fig. 45, SEM.). This semantic aspect of speech—the capacity for understanding the deeper significance of words and the wider meaning of the whole sentence—is really part of the process of true comprehension of the aim and purpose of speech, thought, and action. It is dependent upon the complete integrity of the cortical connexions linking the tactile with the visual and acoustic areas. The functions of this parietal territory are as significant for the real understanding of events as the prefrontal territories are for the attainment of muscular skill, although in all its activities almost every part of the cortex plays its part.

When Man began really to examine the objects around him he did not neglect the study of himself. The information he acquired of the world included a knowledge of his own body and the estimation of the aesthetic qualities of his fellows. I have already referred to the fact that vision came to acquire an increasing influence in his selection of sexual mates; and it is possible that in the case of the Human Family Darwin's claim for sexual selection may find much ampler confirmation than most biologists are inclined to attach to it in the case of other organisms. No one can question the appeal of physical beauty to mankind, and it is difficult to believe that an attraction so universal and deep-seated could possibly have been devoid of effect in the process of transmuting the uncouth form of an Ape into the graceful figure of a human being. This instinctive impulse to study the physical qualities of one's fellows and discriminate between them stimulated the curiosity of each individual to study himself and provided the comparative standards whereby to

estimate his own characteristics. In this process of self-examination vision is aided by the sense of touch. Each individual uses his hands to explore his own body and to learn to appreciate its qualities.

But Man did not examine merely the physical form of himself and mankind in general. He studied the behaviour of his fellows. By introspection he examined his own thoughts and feelings, and constructed his conceptions of time, space, and materials. In his attempts to interpret what he saw and learned by experiment he tried to understand such of the forces of Nature as seemed to affect his welfare. Out of such gropings there emerged the earlier theories of physics and biology, which, handed on from generation to generation, became stereotyped by tradition. At every stage of his progress towards a fuller enlightenment such conventions became for the vast majority of mankind a simple device for escape from the necessity of thinking. Stereotyped opinions and conventional errors imposed upon the community a discipline of behaviour, to which the majority of people conform automatically as the obvious and least exacting thing to do. But if such traditional evasions were a relief from effort and a source of comfort to the many, they have ever been a hindrance to the real thinker striving after a consistent and really satisfying explanation of natural phenomena and human history.

Right-handedness.

One of the most distinctive features of the human brain is a much more obtrusive asymmetry of the cerebral hemispheres than that of any other Primate. It is found equally in *Pithecanthropus* and *Eoanthropus*, as in all the higher types. It affects not only the relative proportions of many areas of the cerebral cortex in the two hemispheres, but also the number (and the degree of conformity to the usual plan) of the nerve fibres that connect the cerebral cortex with the rest of the nervous system. Anomalies—apparently due to 'overcrowding'—of the fibres passing from the

left cerebral hemisphere to the right side of the brain-stem and spinal cord[1] are much more common, and distinctive of Man, than is the case of those arising from the right hemisphere, or the brains of other Primates.

These conditions of asymmetry are intimately correlated with the functional asymmetry of most human beings that confers upon one hand, usually the right, a greater aptitude for the attainment of skill than the other. As I suggested earlier in this work, the ability to learn by individual effort and initiative highly complex movements necessarily implies that attention must be fixed upon one hand or the other, and not on both simultaneously.

The London Skull and Left-handedness.

In November 1925 a fossilized fragment of a human skull was found in the city of London that raises the issue as to the meaning of the asymmetry of Man's brain.

It is just a century since Charles Lamb was pensioned and left East India House in Leadenhall Street; and the place where the gentle Elia, in the intervals of his clerical labours, conceived his imperishable essays is now occupied by the new building for Lloyd's, in the process of the construction of which a vast excavation, 50 feet deep, was made in 1925. For 14 feet below the present level of the street remains of the former Roman occupation are visible; lower down 12 feet of undisturbed 'dirt' rest upon 14 feet of river gravel, below which (that is, 40 feet below the street level) is the blue clay. In March (1925) the ulna of a woolly Rhinoceros (*Rh. antiquitatis*), and six months later part of a human skull, were found in the blue clay. There can therefore be no doubt of the remote antiquity of the original owner of the skull, who was a contemporary of the woolly Rhinoceros and the Mammoth

[1] G. Elliot Smith, 'On the Nature of the *Faisceau en écharpe* of Féré', *Review of Neurology and Psychiatry*, vol. 5, 1907, p. 360.

in what is now the heart of the city of London. But as the Third Terrace of the Thames, in which it was found, is supposed not to have been deposited until after the disappearance of Neanderthal Man from Europe, this is presumptive evidence that the fossil is unlikely to belong to the extinct species (*neanderthalensis*), and that it cannot be earlier than the Aurignacian Period. This skull of the Upper Palaeolithic Period, however, represents the earliest human remains yet revealed in the city of London.

The fragment includes most of the occipital and left parietal bones, and part of the right parietal. The closing of such parts of the sagittal suture as are represented in the fossil and of the lambdoid suture (excepting its lowermost part) and the endocranial suture in the neighbourhood of the lambda (Fig. 47) suggests an age of at least thirty years and possibly something between forty and fifty years. The exceptional smoothness of the skull and the faintness of the muscular impressions in a person of middle age indicate the probability that the sex was female. The reasons for claiming that 'the lady of Lloyd's' was left-handed are discussed in a later paragraph.

The exceptional flatness and distinctive profile of the cranium reveals almost an identity in size and shape with those of the two women (i. e. the Gibraltar and La Quina skulls) of the Neanderthal species; but the flattening of the cerebellum in the latter in comparison with its fullness in the London fossil mars the completeness of the resemblance to the Neanderthal type.

But the likeness of the cerebral part of the endocranial cast in the London and Neanderthal women involves not only the contour of the outline but also the modelling of the surface. In the cast of the London skull the temporal boss (Fig. 46, *T*), to which reference has already been made in the case of more primitive types (see Fig. 42), is still present, and the parietal area (*P*) above it almost as flattened as it is in the Neanderthal casts. In fact, there is a striking resem-

blance to the configuration of the La Quina cast. The maximal breadth of the intracranial cast (136 mm.) is intermediate between the measurements of the La Quina (130) and the Gibraltar casts (140). It is obviously impossible to measure the cranial capacity from this fragment; but by comparison with the Gibraltar skull (itself imperfect) one can safely say that the cubic content of the London cranium cannot have exceeded 1,200 c.cm. by more than 50 c.cm. at the most, that is, it is only slightly larger than that of the exceptionally primitive Piltdown skull.

Although many of the crania of Upper Palaeolithic Men are flatter than those of the average Modern Man their height approaches more nearly to the latter than to that of the London skull, which in this respect agrees with the Neanderthal standard. In other words, the London skull more nearly resembles the Neanderthal type than any other of the Upper Palaeolithic specimens does. The likeness is so real as to raise for serious consideration the possibility whether in Britain a stray member of the Neanderthal species may not have survived after the Mousterian phase of culture had been superseded by the Aurignacian.

Apart from the age of the fossil (that is, its deposition in beds later than that associated with Neanderthal Man), the form of the cerebellum and its bony receptacle, the thinness of the cranium, and the slightly greater fullness of the parietal area suggest that 'the left-handed lady of Lloyd's' was an exceptionally primitive member of the species *sapiens* rather than a belated Neanderthaloid. Though the London cranium is no thinner than the La Quina specimen, this is exceptional for a member of the Neanderthal series. Hence it must be given due weight as a reason for excluding the Londoner from the latter species.

Without the front of the cranium or the face it is unjustifiable definitely to exclude the possibility that this skull may belong to the Neanderthal species; but I think the probabilities are against such a conclusion,

both on anatomical and geological grounds. This uncertainty does not diminish the interest of the London skull; for the enigma of its affinities emphasizes how closely a primitive type of *Homo sapiens* may approach the Neanderthal species (see p. 140).

Reference has already been made to the probability

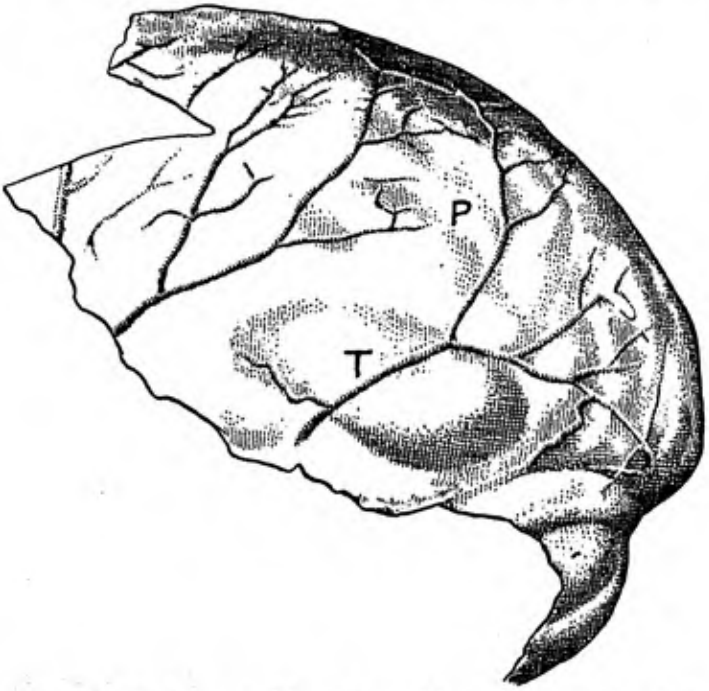

FIGURE 46. Left aspect of the endocranial cast of the London skull to show the temporal boss (*T*) and the defective parietal area (*P*).

that 'the lady of Lloyd's' was left-handed. Some explanation will be demanded in justification of this claim.

In 1906, when investigating the occurrence of the so-called *Affenspalte* (sulcus lunatus) in the human brain, I called attention to the fact that it was often found as a large semilunar furrow on the left hemisphere (Fig. 37, p. 147), but rarely on the right. Moreover, I recorded the observation that the cortical territory,

for which I coined the term 'area striata', was often raised into a prominence behind the sulcus lunatus (as in the Egyptian brain shown in Fig. 37). Corresponding to this prominence there is often a deep depression on the left side of the occipital bone (fossa corticis striatae), surrounded by a ridge (crista lunata) corresponding to the sulcus lunatus. In the winter of 1907–8 Professor F. Wood Jones collaborated with me in the attempt to discover the significance of the occasional reversal of the asymmetry usually found in the cerebral hemispheres.[1] In his field notes on the skeletons found in the course of the archaeological survey of Nubia he recorded whether the right or the left humerus was the longer, and on this basis inferred, in the case of each skeleton, whether the individual was right-handed or left-handed. Using these data I discovered that when the deep fossa striatae and the extensive crista lunata were on the right side, and not on the left, it afforded a reliable criterion of left-handedness. The London skull affords an excellent illustration of this phenomenon (Fig. 47). On the right side (left of the figure) there is a prominent and extensive crista (*L*) and a deep fossa striatae, whereas upon the left hemisphere there is only a very diminutive fossa. This is a reversal of the customary arrangement (seen in Fig. 48), and, I believe, affords definite evidence that the earliest-known Londoner was left-handed.

The question has been raised by several critics as to the validity of these inferences from the size of the humeri as indications of right- or left-handedness. Since 1845, when Arnold raised this problem for consideration, an extensive literature has accumulated from the repeated discussions of the asymmetry of the human body and the difference in the length of the

[1] The cranial signs of right- and left-handedness were discussed by me more fully in a paper read in the Section of Anatomy at the Annual Meeting of the British Medical Association in 1908. An abstract of the paper was published in the *British Medical Journal* of 29 August 1908 (p. 596).

right and left arms. An admirable summary of these discussions is given by the late Professor Gaupp in two small books published at Jena in 1909.[1] On page 7 of the former he summarizes the researches of Arnold, Rollet, Matiegka, Hasse, Dehner, and Guldberg on the question of the excess in length of the left or right arm,

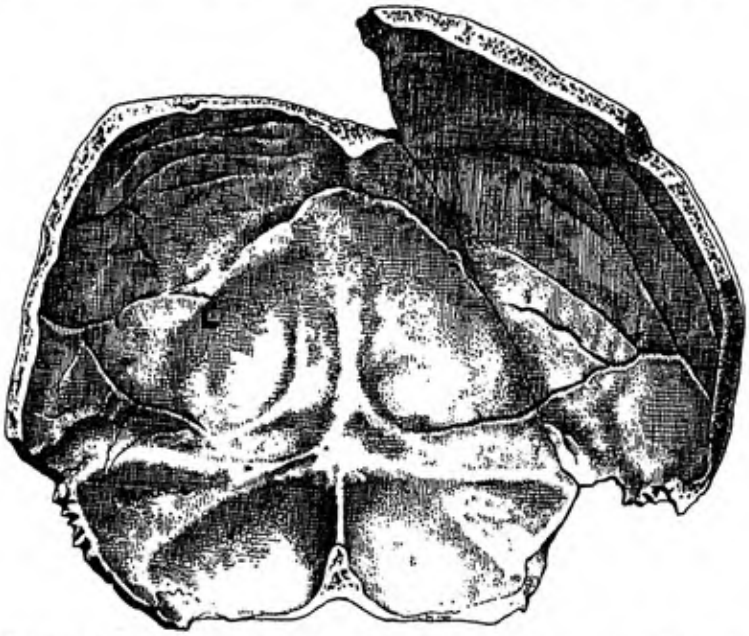

FIGURE 47. The interior of the London skull viewed from in front. *L*, the crest corresponding to the lunate sulcus. T. L. Poulton.

and shows that these differences are usually associated with left- and right-handedness respectively. However, he calls attention to the fact that at the time of birth the length of the bones in the two arms is identical. In other words, the asymmetry manifests itself in the course of post-embryonic life. Gaupp further points out that occasionally it happens (in people whose occupation compels them to exercise the left arm more than the

[1] *Über die Rechtshändigkeit des Menschen*, and *Die normalen Asymmetrien des menschlichen Körpers.*

right) that a person with a congenital tendency to right-handedness may have longer and stronger bones in the left arm. This state of affairs, however, is altogether exceptional, and should not be allowed to discredit the clear inference from a large mass of evidence that the length of the arm-bone in the great majority of cases is a safe indication of right- or left-handedness.

During the course of his work in Nubia in 1907 Professor Wood Jones attempted to correlate his observations on the skeletons of the ancient inhabitants of Nubia with the conditions found in living Egyptians, and he discovered that in right-handed living people the left clavicle was longer and thinner than the right. Then, proceeding to examine the bones in the skeletons, he found in those cases where the right humerus was longer and stronger than the left that the left clavicle was longer and thinner than the right. Moreover, he found that when the clavicular condition was reversed (and the right one was longer and slenderer than the left) the left humerus was then the bigger bone. He regarded this as a confirmation of the use we had made of the humerus as an indication of right- or left-handedness.[1]

Looking through any extensive collection of measurements of human skeletons, it will be found that the means of the lengths of the right humerus are definitely greater than those of the left.

The asymmetry of the brain (Fig. 48) that is associated with this asymmetry of the limbs is not restricted to Modern Man. It is characteristic of the Human Family as a whole, and it seems to be one of the distinctively human traits revealed in most of the known fossil material. For instance, in the cast of the braincase of the La Chapelle Man, which has been described

[1] The reference to this observation is found in the Report on the Human Remains (p. 252) in the *First Annual Report of the Archaeological Survey of Nubia* for 1907–8, which was published at Cairo in 1910.

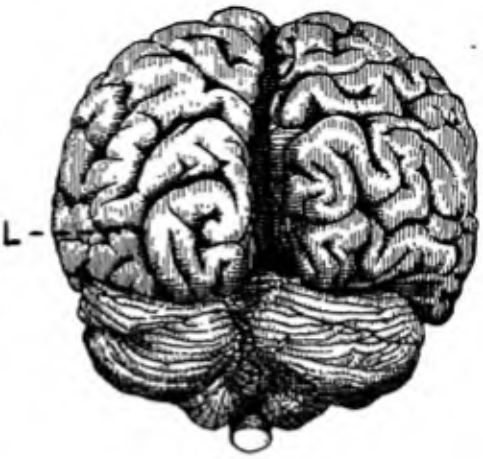

FIGURE 48. The posterior aspect of the brain of a right-handed Englishman with the normal asymmetry — large lunate sulcus (*L*) on the left hemisphere.

FIGURE 49. Similar view of the endocranial cast of the London skull with the large lunate sulcus (*L*) on the right—reversal of the normal asymmetry.

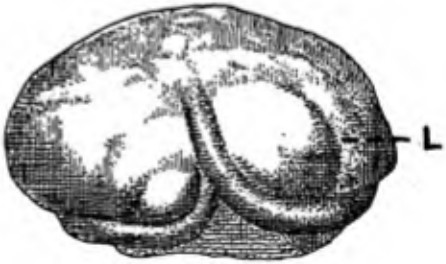

FIGURE 50. Similar view of the endocranial cast of *Pithecanthropus*, with large lunate sulcus (*L*) on the right hemisphere.

by Professors Boule and Anthony, a large lunate sulcus is shown upon the left hemisphere, and in this skeleton the right humerus is longer than the left. In the Neanderthal group as a whole, however, the asymmetry of the posterior ends of the cerebral hemispheres is much less obtrusive than it is in most of the other groups. But in the cast of the brain-case of Rhodesian Man the lunate sulci are as nearly symmetrical as they are in the Anthropoid Apes. In the London skull, as I have already pointed out, the asymmetry is reversed (Fig. 49). In the course of the discussions this statement has excited I realized the fact, which had escaped my attention before, that the same type of reversal is found in the cast of the most primitive human brain-case available for examination—that of *Pithecanthropus* (Fig. 50). In examining this cast a very large and distinct lunate sulcus (*L*) is found upon the right hemisphere. On the left it is so indistinct that its identity is doubtful; but the area behind it is much smaller and especially less prominent than that of the right side. As in the London skull, the superior longitudinal sinus turns in the normal way to the right side; but, for the reasons which have already been given in the case of the London skull, there can be no doubt that this earliest known human being was also left-handed. The asymmetry of the occipital end of the brain affords corroboration of the view that *Pithecanthropus* was definitely a member of the Human Family. Equally definitely *Eoanthropus* (Fig. 18) was right-handed. In other words, the asymmetry of the brain is as old as the Human Family itself, and is a fundamental character distinguishing Man from all other members of the Order Primates.

Attempts have been made in the past to determine whether extinct members of the Human Family were right- or left-handed by a study of the implements made by these people. But so far as I am aware no one has attempted to solve this problem directly by a consideration of the fossil remains of Man himself.

The evidence of asymmetry of the brain to which I have called attention throws a light on this problem that is much more reliable than any inference which can be made from Man's handiwork.

The question naturally suggests itself whether there is any trace of asymmetry in the Anthropoid Apes. It can be seen at a glance that although the two cerebral hemispheres in the Anthropoid Apes are approximately symmetrical and do not reveal the obtrusive asymmetry found in most human beings, the superior longitudinal sinus does not always split into branches of equal size, as so frequently happens in the lower Apes. In the Gorilla, in particular, the sinus often turns to one or the other side; and there seems to be a slight preference for the right side, as in the case of the human sinus. Although there is no definite asymmetry in the brain, some interesting facts, collected by Gaupp from the writings of Mollison, von Bardeleben, and others, suggest the remarkable conclusion that the bones of the right arm are longer than those of the left arm in the Gibbons and Orangs (as in Man), but the bones of the left arm are longer in the Chimpanzees and Gorillas. These writers contrast this asymmetry in the Anthropoid Apes with the symmetrical condition found in the Monkeys. Though there is no obvious asymmetry of the brain, there seems to be in the (apparently ambidextrous) Anthropoid Apes an instability that affects the symmetry of the limbs, although neither the right nor the left is so definitely selected as in the case of the vast majority of human beings.

Taking into consideration the fact that the cortical territory concerned in the causation of the lunate sulcus is the visual area, it is of some interest to note that B. S. Parson, in his book *Left-handedness* (1924), came to the conclusion that the ocular dominance—that is, the use of one eye for fixation—determines both cerebral dominance and the 'handedness' of the individual.

The apparent asymmetry of the visual cortex, that of the left side associated with the right field of vision

appearing to be considerably bigger than the right, at one time deceived me into believing that the area striata was actually bigger on the left than on the right side. But careful measurements of this region in the two hemispheres ultimately convinced me that appearances were illusory, the apparent differences being due, not to the contrast between the visual areas of the two hemispheres, but to the mode of packing. The larger parietal area on the right hemisphere usually pushes back the area striata farther than happens on the left.[1]

In all these discussions it must be remembered that even if the right- or left-handedness does not make its appearance until well on in the first year of life, it is due to congenital tendencies that manifest themselves at this relatively late time. It must also be remembered that these congenital tendencies may in many cases be overcome to a considerable extent by training; so that it is possible to get a brain showing the asymmetry distinctive of left-handedness with limbs which show the conditions usually associated with right-handedness.

By making it incumbent on most children to learn to read and write modern civilization has created special difficulties for many of those who have an innate tendency to employ the left hand for skilled work. When such children are compelled to train the right hand this involves the education, so to speak, of the left cerebral hemisphere (controlling the opposite side of the body and limbs) to do what in these particular individuals would naturally be done by the right cerebral hemisphere. This often leads to a defective control of muscular activities, such for example as express themselves in stammering, and a difficulty in learning to read and to recognize words. But these defects represent only a small part of the disabilities such children are liable to suffer. For their ineptitude may be mistaken for stupidity or some such

[1] See my memoir in *Anat. Anzeiger*, 1907, Bd. xxx, p. 574.

pathological condition as that often labelled 'word-blindness'. Moreover, there is the torture of being misunderstood and of being teased by fellow children for not doing things in the customary way or of being 'defective'. To a sensitive child the mental conflicts that may arise from such causes may have serious consequences on the temper and character and affect his attitude to his fellows.

A very suggestive discussion of the visual factors involved in left-handedness has recently been submitted[1] by Dr. Samuel T. Orton, of the Iowa State Psychopathic Hospital, which I shall freely use in my further references to this subject.

The impulses from the two eyes are carried to the areae striatae of the two cerebral hemispheres, which are identical in size and structure. Each area striata, however, is a mirrored counterpart of its fellow. Hence one must assume that when visual attention is fixed upon any object the effect of the stimulation of the eyes excites a pattern of activity in the right area striata, which is the reverse—in other words, the mirrored image—of that in the left area striata. Binocular perception is effected by the psychological fusion of the two sensory images. Loss of the ability to recognize the meaning of objects seen (mind-blindness) occurs only when the appropriate areas of *both* cerebral hemispheres are damaged. But loss of symbolic meaning (word-blindness) occurs when *one* hemisphere only is affected. Injury to a particular area in the left hemisphere (in a right-handed person) can destroy the power of remembering the symbolic value of any group of visual signs that the individual in question has learned to associate with a certain sound or word. Here there is no question of fusion of images. In the process of learning to read there is stored up in each hemisphere the record of signs that in the process of visual education are associated with certain sounds and meaning. In the

[1] '"Word-Blindness" in School-children', *Archives of Neurology and Psychiatry*, 1925.

right-handed child the left hemisphere plays the dominant part in this particular function; and in course of time the mirrored symbolism due to the activity of the visuo-perceptive areas of the right hemisphere becomes suppressed. Then he reads with his left cerebral hemisphere. But until this happens there is in young children, as Miss Lucy Fildes[1] has so clearly demonstrated, a common tendency to mirrored or reversed writing, suggesting that in the right hemisphere of the right-handed and the left hemisphere of the left-handed there is a mirrored image of the letters and words, the recognition of which in their proper orientation depends upon the other hemisphere. Hence if a left-handed child is compelled to use the right hand this tendency to mirrored writing and, if I may coin a term, mirrored spelling, becomes intensified, and adds enormously to the difficulty of writing and spelling correctly. The child who has to overcome such obstacles and the anxieties that such efforts provoke clearly suffers from a very serious handicap.

In the case of the six-year-old boy with an hereditary tendency to left-handedness discussed by Fildes and Myers[2] there was a striking tendency towards mirrored reversal of letters and uncertainty in recognizing the correct right-left orientation of many of them. He had just begun to be taught to write with his right hand, with which he experienced exceptional difficulty. He began to stutter at the same time. The training of the left side of the brain to direct complicated acts of phonation that hitherto had been controlled (*in the opposite way*) by the motor mechanisms of the right hemisphere would obviously hamper the display of such muscular skill as is essential for articulate speech. Hence stuttering is the result of this conflicting control —the ineffectual attempts to enunciate by a reversal of the proper muscular action—until the process is reversed again to effect the desired result. In the case

[1] *Brit. Journ. Psychol.*, 1921.
[2] Lucy G. Fildes and C. S. Myers, ibid.

of the child mentioned, when permitted to write with the left hand, the confusions of orientation and the impediments in speech rapidly disappeared.

The reality of these reversal effects (training the right hand and the left side of the brain producing a mirrored effect upon the right side of the brain) was displayed in a very emphatic way during the war in the process of re-educating men who had lost their right hands. Some of these men, after weeks or even months of training, were unable to write with their left hands. Yet in a few hours these same men acquired great skill in mirrored writing, so that by putting a carbon paper under their writing-paper they were able with great facility to write a script that was perfectly legible in its reversed form on the back of the sheet.

EPITOME

In these pages I have been trying to suggest some of the leading factors that helped to confer upon Man his most distinctive attributes, intelligence, discrimination, skill, the erect posture, and the aptitude to learn from experience. The great conclusion that emerges is that the seeing eye guiding the adaptable right hand conferred upon Man his intellectual supremacy because the brain developed in such a way as to make learning and understanding attainable through the practice of skilled manipulation.

Once a trustworthy restoration of Man's pedigree is made and the sequence of changes that occurred in the history of the bodily—and especially cerebral—structure of his ancestors is established the way is open for inquiries as to the meaning of the events that were responsible for conferring upon Man his distinctive attributes of mind and body.

With the emergence of Vertebrate animals a type of brain came into being, which was distinguished by an unbroken continuity of nervous tissue permitting more intimate correlation between its different parts

than was possible in the chain-like type of gangliated cord that forms the central nervous system of Invertebrate animals. Playing upon this adaptable instrument the dominant sense of smell was able to link together series of experiences that appealed to any or every sense and unite them into a coherent state of consciousness covering the train of events from primary scent that starts the reaction, the duration of the pursuit, and the attainment of the aim of it.

The olfactory sense is, so to speak, the cement that binds into one experience all the events that intervene between anticipation and consummation. By conferring upon consciousness the element of cohesion it makes possible the ultimate appreciation of time and space, the ability to look backward and forward, to remember and to anticipate. In these possibilities lies the germ of the aptitude to learn from experience and to attain skill in modifying behaviour in accordance with the changing conditions of the outside world.

In this book I have attempted to explain the salient phases of the process whereby the lowly vertebrate equipped with these vast possibilities of achievement gradually attains the realization. The long rivalry between the controlling influence of smell and sight, each specially fitted to acquire kinds of information that were in a sense complementary one of the other, was at last adjusted in mammals, when vision obtained adequate representation in the cerebral cortex, so that a fuller reliance upon the guidance of the eyes no longer hampered progress by diminishing the importance of the leading (olfactory) segment of the brain.

The transference of the visual sensorium to the neopallium created the possibility for more intimate correlation of visual experience with that acquired by touch, hearing, smell, &c.; but in addition it conferred visual guidance on the limbs in the process of learning to acquire new modes of action.

The full exploitation of such possibilities could not be realized until the cerebral cortex also acquired

control of the automatic mechanisms for regulating posture and the tone of muscles. When this happened the possibility of attaining real skill in work and play was created. Not only was the neopallium then able directly to release the tone of muscles so as to make them more apt to obey its influence, but the way was also opened for it directly to participate in the process of integrating more completely voluntary movements with automatic postural and tonic reactions, and so building up these acquired automatisms which we call 'skill' by the process of acquiring them that we refer to as 'training'. The essence of attaining skill is training the muscles of the body to perform movements with less effort and less attention than are needed for non-habitual actions. Man's neopallium has acquired control of posture and the tone of muscles. It is able to bring these automatic powers into harmony with voluntarily acquired movements, and thereby saves the individual from undue fatigue in performing these acquired automatisms. But, in addition, once they have by training been made really automatic the individual's attention is free to introduce, in adaptation to new circumstances, slight changes that represent the perfection of skill.

Man enjoys an immeasurable advantage over all other living creatures in these aptitudes for acquiring skill and in circumventing fatigue. His erect attitude and his manual dexterity are expressions of this newly acquired competence. But the mere process of learning gives him knowledge and understanding, appreciation of form and beauty, and the powers we significantly call insight, foresight, and the wider vision.

BIBLIOGRAPHICAL NOTE

As this little book will be used as a guide by many students not familiar with anthropological literature, perhaps I should indicate where fuller particulars concerning the evidence discussed here can be obtained. The most useful introduction to such studies is T. H. Huxley's *Man's Place in Nature* and Charles Darwin's *The Origin of Species* and *The Descent of Man.*

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